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THE RELATIONSHIP OF WORK TRIPS TO

EMPLOYMENT CONNECTED SOCIAL

AND ECONOMIC FACTORS

A THESIS

Presented to

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EMPLOYMENT CONNECTED SOCIAL

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GLOSSARY

V	Rating assigned to occupation by judge
u	Utility rating value for occupation
X_{ij}	The i^{th} observed variable on the j^{th} individual.
b_{ik}	The i^{th} factor loading of the k^{th} common factor.
f_{xj}	The k^{th} common factor relating to the j^{th} individual.
S_{ij}	The i^{th} unique factor relating to the j^{th} individual.
u_i	The weight of the i^{th} unique factor.
e_{ij}	Error of the i^{th} observed variable relating to the j^{th} individual.
C_i	Weight of the i^{th} error term.
ℓ_i	Direction cosine of the components to be determined with the axis X_i.
$\underline{r}$	Matrix of simple correlation coefficients of the observed variables.
E_i	Eigenvalue corresponding to the i^{th} component.
x_1	Average occupation level.
x_2	Average distance of travel between home and place of work.
x_3	Floor space.
y	Number of trips attracted to the work centers.
ϕ	Varimax angle of rotation.

SUMMARY

Beginning in the 1950's, transportation planning became more scientific in nature and analytical techniques were introduced to quantify the travel characteristics and the need for future transportation facilities. Today, the transportation planning philosophy has become a comprehensive and continuing process as required by the U.S. Government. This process is composed of a series of four phases: 1) inventories, 2) analysis of existing conditions and calibration of forecasting techniques, 3) forecasts of future conditions, and 4) analysis of future transportation systems.

This thesis is concerned mainly with the phase of inventories and with the work attractions trip generation block of the phase analysis of existing conditions and calibration of forecasting techniques.

The phase of inventories is the most expensive one. This high cost is partly a result of collecting redundant social, economic and travel variables. This fact was noted by several authors whose recommendations were to study the interrelationships between these variables.

The work attractions trip generation block of the phase analysis of existing conditions and calibration of forecasting techniques consists of determining a mathematical model relating the number of work trip attractions to the variables collected in the inventories phase. The mathematical technique used to determine this model is multiple linear regression which assumes that the dependent variable is the only random variable of the model and the independent variables are not correlated with each other. Such assumptions do not often apply to socio-economic

data which are usually interrelated and are random in nature. Several investigators noted the violations of the above assumptions to be the reason of not obtaining satisfactory models in fitting their data.

This dissertation seeks to investigate the following two points: 1) study of the degree of association between the employee socio-economic and travel variables, and 2) determination of a work trip attractions model having causal and functional characteristics. The first point was investigated by analyzing data collected from the employees of 20 large work centers located in the Atlanta Metropolitan Area. This analysis was performed using factor analysis and multivariate statistical technique. The second point was investigated by analyzing the employee and employer connected variables of these 20 large work centers. This analysis was performed using component analysis multi-variate statistical technique.

Thirteen employee quantitative variables were analyzed using factor analysis. These 13 variables collapsed into a maximum of six factors: 1) Travel factor having the variables time and distance of travel associated with it, 2) Home-characteristic factor having the variables home value, rent, and lot size associated with it, 3) Car-ownership factor having number of cars variable only associated with it, 4) Family-size factor having the only variable number of children associated with it, 5) and 6) Status factors having the variables education, occupation, income, family income, age, and years at work associated with them. These factors with the exception of the travel factor were affected by the qualitative variables: sex, marital status, and mode of travel. The choice of non-collinear employee variables from the factors obtained should depend on the ease, economy of collecting data, consistency and stability of the variables, and purpose of the study besides the degree of association criterion.

The employer and employee variables analyzed for the work trip attractions by work centers model collapsed into three related variables: floor space, occupation level and average distance of travel between home and place of work. The component regression model obtained confirmed the previous findings on the strong relation between the number of work trip attractions and the floor space variables. The model also showed that the work centers that have the greater number of work trip attractions are the ones that employ a larger number of blue-collar workers. Conversely, the model suggests that the larger work centers tend to attract workers from a greater distance from the center in order to satisfy their larger demand of skills.

CHAPTER I

INTRODUCTION

In the past fifty years the United States has changed from a predominantly rural and agrarian country to one in which about three-fourths of its people live in urban areas. The official census shows that the urban population of the United States was only about forty percent in 1910, while this figure was increased to seventy percent in 1960(1).* This rapid urbanization phenomenon was made possible by the advances of agricultural productivity and the opening of new employment opportunities in industry and trade (2).

This change in the nature of employment that resulted from industrialization, had a significant impact on the structure of the American society. The individual American became more affluent, and thus had more desire to consume and to increase his standard of living. This increase of standard of living was expressed in higher car ownership and in larger scale development of single family housing units in the suburbs. This new location of housing facilities in the suburbs has caused a great increase in the distance of travel between home and work place (3); also, this land development, being low in density, could not be served economically with public transportation, and hence the automobile became the predominant mode of travel (4).

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* Numbers in parenthesis refer to bibliographic references listed at the end of the thesis.

In parallel with this increase of travel distance and the large dependence on the automobile, there was little planning, if any, done in the urban areas to adjust to these conditions. This lack of planning resulted in the pathological situation of traffic congestion that occurs twice a day on the highways of the American cities.

Beginning in the 1950's, transportation planning became more scientific in nature, and analytical techniques were introduced to quantify the travel characteristics and the need for future transportation facilities. Today the transportation planning philosophy has become a comprehensive and continuing process as required by the United States government (5). Figure 1 describes diagramatically this process as defined by the U. S. Bureau of Public Roads (6).

This transportation planning process is composed of a series of four phases: 1) inventories, 2) analysis of existing conditions and calibration of forecasting techniques, 3) forecasts of future conditions, and 4) analysis of future transportation systems. The blocks included in these four phases are not sequential, but on the contrary are interrelated as shown in Figure 1, with the different feedbacks from one block into the other.

The phase of inventories consists of collecting data that describe the social, economic and travel characteristics in the urban area. This phase is the most expensive one in the planning process. Partly this high cost is a result of collection of redundant information.

The phase of analysis of existing conditions and calibration of forecasting techniques, consists mainly of determining mathematical

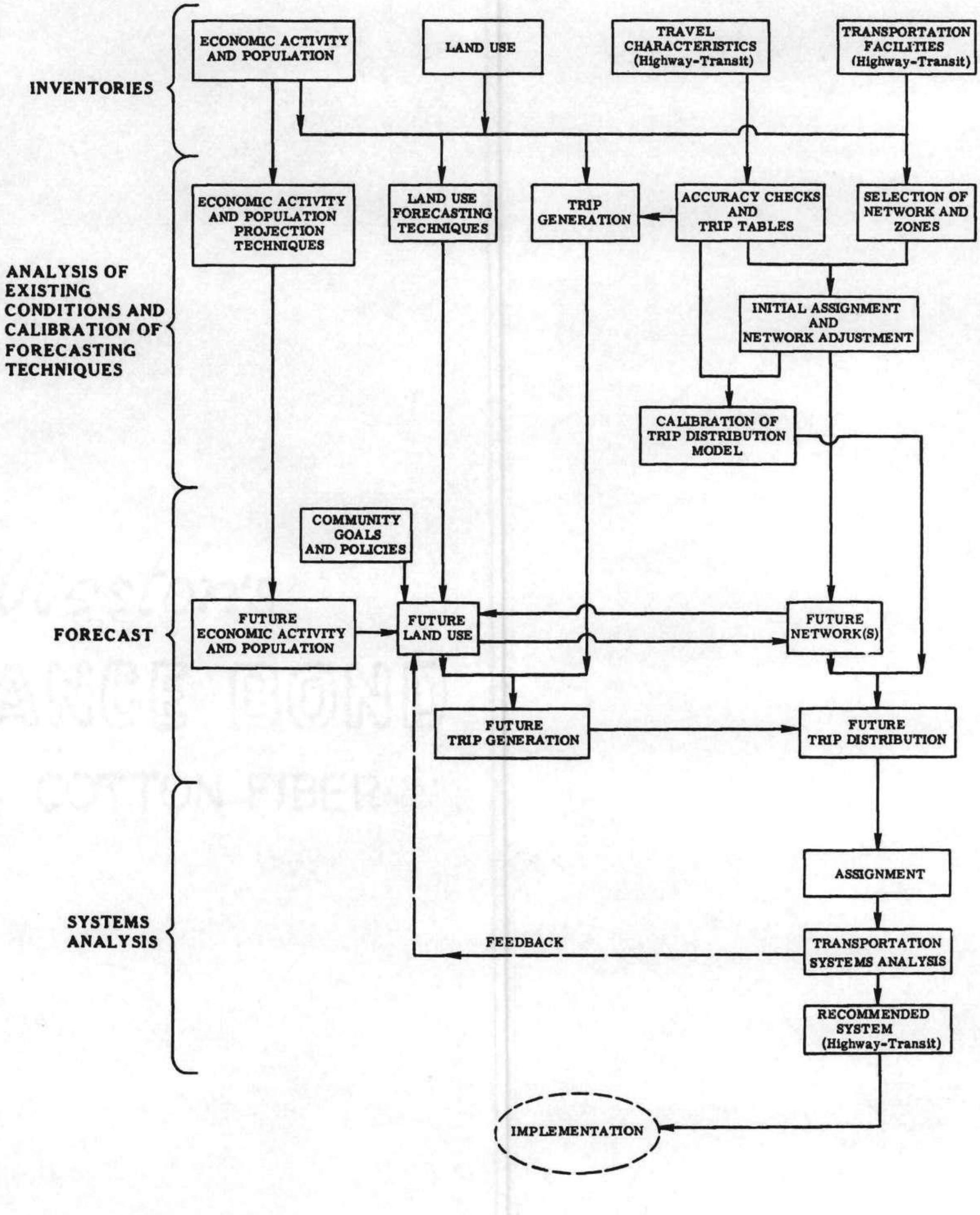

Figure 1. Urban Transportation Planning Process

models to represent the relationship between the variables collected in the inventories phase. These mathematical models are: 1) trip generation, 2) land use, 3) population and economic activities, and 4) distribution and assignment of trips. These models are used to feed in the forecasts and systems analysis phases, in order to determine estimates of future trip attractions and productions and to assign them to the transportation facilities.

This study is concerned mainly with the phase of inventories and with the work trip attractions model of the trip generation block belonging to the second phase of the planning process.

The objectives of this investigation are:

a. To analyze quantitatively the interrelationships between the social, economic and home to work travel variables related to the employee.

b. To determine the independent elements of information available in the social, economic and home to work travel variables related to the employee. This will determine the redundancies and collinearities in these variables.

c. To develop a mathematical model relating in a <u>causal</u> expression the number of work trip attractions to the employee and employer related factors. These work trips will be the attractions by work centers instead of by traffic zones.

d. To present two <u>multivariate</u> statistical techniques that can be used efficiently in the transportation planning process. These techniques are: 1) factor analysis, and 2) component analysis.

In this study, a trip is defined as a one-way journey by a person traveling between his home and his place of work.

CHAPTER II

REVIEW OF LITERATURE AND STATEMENT OF PROBLEM

Between the early 1920's and the late 1930's, the only street and highway travel estimation was based mainly on traffic counting. These traffic counts told little about present traffic desires and practically nothing about future traffic desires and needs. Therefore, planners and engineers started collecting information by directly interviewing the traveller either on the road or in his home. These interviews were part of the origin and destination studies which gave information about the trip origin and destination, the mode of travel, and the routes used. The results of these origin and destination studies were used primarily to describe existing travel patterns, which were simply projected into the future. These existing travel patterns were presented in the form of tables and diagrams. The tables showed the trip origins and destinations and the diagrams, called desire lines, presented graphically the spatial distribution of these trips. These desires were merely extrapolated into the future in order to obtain the future travel volumes (7).

The origin and destination studies were obviously inadequate to estimate future traffic because they were simply a measure of the present travel patterns. This present evaluation of highway travel patterns did not satisfy the planners and traffic engineers who are actually more concerned with the future patterns of travel. Therefore, there was a need for a more accurate traffic estimation procedure which will help the planner to predict trips rationally.

These more accurate trip estimating procedures were the analytical techniques that were brought to the transportation studies after the results of the San Juan, Puerto Rico study. Carril (8) reported the results of this study by pointing out the possibilities of developing relationships between land use and travel data for the purpose of travel prediction.

Following the results of the San Juan study, several investigations were undertaken in order to study the relationships between the data collected in the transportation studies. These investigations can be grouped into two main groups: 1) studies on the separation of home and place of work, and 2) studies on the estimation of future trip ends.

The studies on the separation of home and place of work have as goal the establishment of relationships between land use, socio-economic, and travel characteristics for the understanding of the variables that shape and form the structure of the urban areas (9).

The studies on estimation of future trips are called Trip Generation Analysis whose ultimate goal is to establish an adequate functional relationship between trip end volumes and the land use and socio-economic characteristics of the units from which they originate or to which they are destined (10).

The remainder of this chapter will discuss briefly the previous investigations of each of the two groups of studies.

Studies on Separation of Home and Work Place

There have been several significant studies on the separation of home and work place in urban areas. The objective of the early studies, in the United States, was to minimize the distance between home and work in order to reduce the consumption of tires, metals, gasoline, and construction materials that were in critical shortages because of the second world war (11). However, the results of some of these war studies were used later by several people for planning purposes.

Carroll (12) in 1950 used the results of the survey of war productions in Massachusetts in his doctoral dissertation about the journey between home and work place. This thesis was the first study, in the United States, to approach the problem from a broad view. In his findings, he hypothesized that the distance between home and work place was directly related to the population of urban areas. Later Beyer (13), studied the effects of social and economic variables on the distance between home and work place. He noted that families that lived far from their place of work have higher incomes and are younger than those who lived near their place of work. He also mentioned that those who live farther have better education and their homes have larger land lots.

Kain (14) included in his study an additional social variable, race. He concluded that people of low income groups live nearer to their place of work and that since non-whites belong to these groups, they tend to live near the central business district where they work.

Voorhees (15) found in a recent investigation that the work trip length was proportionally related to changes in the population of metropolitan areas and is a direct function of family income. He also pointed that there are certain non-random factors that could be used to predict trip length.

Catanese (16) in 1969, for his doctoral dissertation, studied in detail the separation of home and work place in two urban regions in the United States. He stated that

> "Family income dominates as a socio-economic force. Such other variables as education, age, occupation, status, and race are more related to income than to home-work distance ..., each of these variables has a specific and interesting set of associations with home and work place separation. These associations should be studied to add to our knowledge of urban regions."

He further continued by saying that

> "The knowledge of family income associations provides sufficient and necessary conditions for explanation and prediction. This becomes quite meaningful, in a cost reduction sense, for analysts. In fact, through analytical study,it is possible to use family income to generate other socio-economic variables. This would substantially reduce the costs of data collection and processing."

In the same study, the author mentioned several techniques that can be used to determine the associations between these socio-economic and travel variables, and he described Factor Analysis as the most sophisticated one (17).

It is worth noting that Catanese also presented an excellent description on the implications of the knowledge of the relationships between the socio-economic and travel variables to planning problems such as zoning, land use planning, housing, and transportation planning (18).

Studies on Trip Generation Analysis

A large number of studies appeared in the literature about trip generation analysis. These studies were concerned with developing better functional relationships that would be practical in their application and would provide a better understanding of the forces affecting travel patterns. In order to achieve the above objective, different investigators used different approaches. However, these approaches can be grouped into three basic categories: 1) those that investigated which socio-economic and travel attributes should be used in predicting trip ends, 2) those that generalized available relationships to other urban areas, and 3) those that tried to improve and criticize the usage of the statistical techniques used in the prediction of trip ends.

Previous Studies on Socio-Economic and Travel Attributes

In this category a large number of socio-economic and travel variables was investigated by different authors. Metz and Hamner (19) analyzed the relationships between variables obtained in an Origin and Destination in Washington, D.C. in 1948. The variables considered were: family income, distance from the central business district, car ownership and trips per dwelling unit. Their basic finding was that the number of trips per dwelling unit was highly related to the car ownership variable.

Later, Harper and Edwards (20) studied the relationships between the number of trips attracted to the central business district and land use characteristics. The land use measure used was the floor space area, which was found to be strongly related to the number of trip attractions. The data used was obtained from origin and destinations studies taken in seven metropolitan areas having populations of 250,000 persons or more. It is worth noting that the authors found great similarities in the travel patterns in many of these cities. These similarities, as they stated in their study, were made possible because of the use of person trips irrespective of the mode of travel.

In extension to the Harper and Edwards study, Wright (21, (22), studied for his doctoral dissertation, the relationships of trip attractions to the central business district with land use characteristics, population of the city, and purpose of travel. The land use characteristics he used are: the floor space area and the type of floor space usage. The different types of floor space uses considered are: retail, service, office, manufacturing, wholesale, semi-public, and public space uses. The data analyzed was obtained from Origin and Destination studies of five cities of different populations. He concluded that the number of people attracted to a zone within the central business district is highly related to the floor area used for various purposes within that zone. Specifically he found that the trips attracted to a certain zone for a certain purpose is related to the area of certain classifications of floor space use, and that the rate of trip attraction is significantly related to the city population. The author noted that his results were affected by the size of the traffic zones and that the smaller homogeneous zones produced better and more reliable results. These conclusions influenced the investigator to recommend that future transportation studies should report trips by city blocks instead of zones.

Houston and Linder (23) studied the relationships of socio-economic and land use variables in the St. Louis, Missouri metropolitan area. They found that median family income, car ownership, population density, and relative decentralization were the most significant variables to determine the number of trips generated between traffic zones.

Cherniak (24) in a critique of home interview type origin and destination surveys, suggested that surveys must be undertaken at the place of destination and not at home. He also pointed that it is essential to interview those who travel during the peak hours. The author also presented some relationships between car and household densities and number of trips per acre. He noted that the number of cars per acre does not increase in proportion to the number of households per acre and therefore, he recommended to use household densities as an indicator of car ownership, instead of family income which he criticized as unstable for prediction purposes. He also mentioned that the household densities in an area are best estimators of the number of trip ends.

Barnes (25) in a study on land use and travel forecasting commented that car ownership increased directly with population and with higher incomes. Crevo (26) added that the number of trips per family can be determined directly from car ownership. Shuldiner (27) introduced a new variable to these relationships, the occupation of the head of household, which he found to be the major determinant of the level of living that a family enjoys. He also stated that "the occupation variable should be associated with trip frequency as well as with other household characteristics".

The importance of the occupation variable was also stressed by Michelson (28), and Stowers (29) who found in different studies, that occupation and family size were significant variables in predicting car ownership and thus, as stated, affected the trip-making phenomenon. These results were welcomed by Walker (30), who pursued this line of research in analyzing transportation data from the urban areas around Seattle and Tacoma, Washington, and from the Chicago Area Transportation Study. He found that the occupation variable was a significant factor in trip generation and recommended its inclusion with the car ownership and family size variables, in predicting trips. However, the author added that

> "the interrelationships or interdependence of these variables, are questions to be answered before any reliable predictive model utilizing these variables can be constructed".

Fogerty (31), in his dissertation on trip productions in urban areas, concluded that it is possible to estimate car ownership, labor force and dwelling units variables using population as the estimator. He also noted that the current Origin-Destination studies reflect a great amount of overcollection of data and suggested that this data be analyzed to determine the interrelationships between the variables in order to reduce the cost of collection and analysis.

Black (32), in a study of travel and land use characteristics, compared the land area, floor area and employment variables. His objective was to find the best of these three variables to be used to estimate trips. Using data collected by the Chicago Area Transportation Study, he concluded that floor area rates are best for commercial trip generation, employment rates for manufacturing, and land area rates for public buildings. He also recommended that better results could be obtained in estimating trips when smaller geographical units are used. Walker (33), tried to rationalize the relationship between the trip attractions and the floor and land area rates, by noting that

> "people use land from a transportation planning point of view, because they wish to satisfy certain basic physical and emotional needs, to wit: the need to work, so they may shop for goods and services; the need to play and rest, so they may be rejuvenated in order to continue to work."

Harmelink, Harper and Edwards (34), added another variable to describe the place of employment in a trip generation study. This newly added variable is the assessed value of land and buildings, which they found to be highly related to the number of trip attractions and to the area of land and floor space variables. They also recommended that the assessment value variable is a stable measure of land use and is reliable to be used for prediction of trips.

Recently, a new line of research was introduced by attempting to relate non-work trips to work trips which are regular and stable in occurence, and can be used for prediction more reliably. Shunk and Grecco (35) found "the home based work trips represent an excellent approximation to the important travel patterns of trips of all purposes for peak hour or total daily travel." They also stated that since only work trips would be necessary to investigate, collection of data could be more economical by interviewing a sample of employees at their place of work. Further, Parsonson and Roberts (36) added that the number of work trips assigned to a link of road is highly related to the peak hour volume counts of traffic on that link. They also recommended that urban areas should take traffic peak-hour volume counts concurrently with the 1970 census which in turn is collecting information about the work trip.

Previous Studies on Generalization of Travel Relationships

In this category of studies, the authors strived to apply the models of trip generation obtained from origin and destination studies in one urban area to another urban area where no origin and destination data is available.

Wiant (37) presents the results of a transportation forecast in which a minimal amount of origin and destination data was collected. These forecasts were prepared for seven cities in Iowa; however, all of these forecasts were based upon origin and destination data collected in one city. These forecasts data were used to develop trip ends estimates and time-distance relationships which were then applied to all areas. He also noted that the forecasts were for the year 1980 and their cost for the seven-city study was only $22,500.

Kolifrath and Shuldiner (38) continued in this direction of research, and evaluated the validity of applying trip generation models into several urban areas. For their study, they compared 20 different models of trip attractions to manufacturing land use activities. They concluded that it was reliable to generalize the use of trip generation equations for manufacturing trip attractions.

Schmidt (39), in his doctoral thesis, demonstrated the applicability of a method for comparing trip generation equations developed for different urban areas, and for comparing trip generation equations developed at different times for the same area. He concluded that the trip generation models for home-work trip attractions showed more variation from area to area than those of trip production. He also stated that he had little success in attempting to develop an overall trip generation equation for the category home-other attractions. Furthermore, he recommended a small survey to be undertaken and to be used with his approach as a pilot study whenever there is no origin and destination data available.

Previous Studies and Critique of the Technique of Multiple Regression

In this section, comments and critiques on the usage of multiple linear regression will be briefly presented. This technique is the most commonly used in trip generation analysis. Before attempting to present these comments and critiques pertinent to this technique, it is helpful to describe briefly multiple linear regression procedures and its basic assumptions.

Multiple linear regression technique is

> "a statistical procedure in which the relationship between two or more related items, called variables, may be expressed in an optimum mathematical form according to a specified criteria".

This mathematical relationship is of the form:

$$Y = \alpha_o + \alpha_1 x_1 + \alpha_2 x_2 + \ldots \alpha_p x_p + e \qquad [1]$$

where:

Y = dependent variable,

$\alpha_o, \alpha_1, \ldots, \alpha_p$ = coefficients of the model,

$x_1, x_2, \ldots, x_p$ = independent variables, and

e = error term

The coefficients and the error term of this model are unknown, and the criterion used to estimate these coefficients is to minimize the sum of the squares of the error. As a consequence of the Gauss-Markoff theorem (41), the least squares procedure will result in a set of linear unbiased estimators having minimum variance. In this estimation procedures, the following basic premises are required (42), (43), (44):

(1) The independent variables, x's, are fixed variables that have no error associated with them. All the errors occur only in the dependent variable, y, which is a function of the random error e.

(2) The independent variables, x's, are not correlated with each other.

(3) The variance of the error term is constant for any set of values of the independent variables.

(4) The covariance of the errors is zero. That is to say that successive values of the error are independent.

(5) The mean of the error is zero.

If in addition to the above assumptions, normality is imposed on the distribution of the dependent variable, or the error term, the least squares estimators will also be maximum likelihood estimators of the parameters, and tests of significance may be legitimately applied. Many of these assumptions are often violated in applying multiple linear regression to data of a socio-economic nature. These violations of the assumptions produce mathematical models which have no causal interpretation (45).

Sato (46), in a study of methods for estimating trip destinations stated that the regression analysis of work trips and employment was not satisfactory. He further commented that:

> "It appeared that error existed in both the estimates of employment and the work trip data."

Johnston (47) in his book on econometric methods, discussed the violations of the previously stated assumptions when multiple regression techniques are applied to fit data of economic nature. He stated that: "To be realistic we must recognize that most economic statistics contain error of measurement", and that: "the x_i variables may be very highly interrelated, which is called the problem of multicollinearity", and the assumption that the errors have equal variance is unrealistic in economic data. The author supported this last statement by an example saying that "the savings of households with high incomes may show much greater variation about some mean level than do the savings of households with low incomes".

Deutschman (48), in an article about developing a criterion to select trip generation procedures stated that

> "There has not been a great deal of analytical work published by transportation planning groups on determining the error in estimating independent variables or predictors."

Snyder (49), Wallis (50), and Sharp (51), in three different studies on multiple linear regression failed to obtain satisfactory models in fitting their data. They stated that the regression equations they obtained had highly unstable coefficients, and that the regression coefficients did not represent an estimate of the independent contributions of their respective variables. The reason that they gave for not obtaining causal functional relations was the violation of the first two assumptions pertinent to multiple linear regression analysis.

Summary of Previous Investigations and Problem Statement

In summary of this brief literature survey, the following two points can be stated:

(1) There is a need of studying the degree of association between the socio-economic and travel variables collected in urban areas.

(2) There is a need of applying more reliable statistical techniques in modeling the relationships between these socio-economic and travel variables in order to obtain more causal and functional relationships.

This investigation will attempt to answer these two points by applying multivariate statistical techniques to analyze these socio-economic and home-to-work travel variables. Factor analysis will be used to answer the first point and component analysis to answer the second one.

CHAPTER III

METHOD OF STUDY

The method of study used in this investigation was to collect data from employees and employers in the Atlanta Metropolitan Area, and to analyze this data using multivariate statistical techniques.

Data Collection

Because of the absence of social and economic, and travel data by work centers, it was necessary to undertake a survey for the purpose of this study. The Atlanta Metropolitan Area consisting of the five counties: Fulton, DeKalb, Cobb, Gwinnett and Clayton was chosen for this survey. This five-county metropolitan area, shown in Figure 2, extends over 1,724 square miles and had a 1969 population of 1,302,000. The central city of the area, Atlanta, contains more than one third of the Area's population and occupies nearly 140 square miles of Fulton County and eight square miles of DeKalb County (52). This central area is the center of the southeast region of the United States and has a diversified economy ranging from industry to services (53).

Twenty work centers, having large number of employees, were selected from the whole metropolitan area, including its central business district. The employees of these work centers were surveyed over the period extending from January to April, 1970. This survey covered a population of about 25,000 employees working in the 20 work centers.

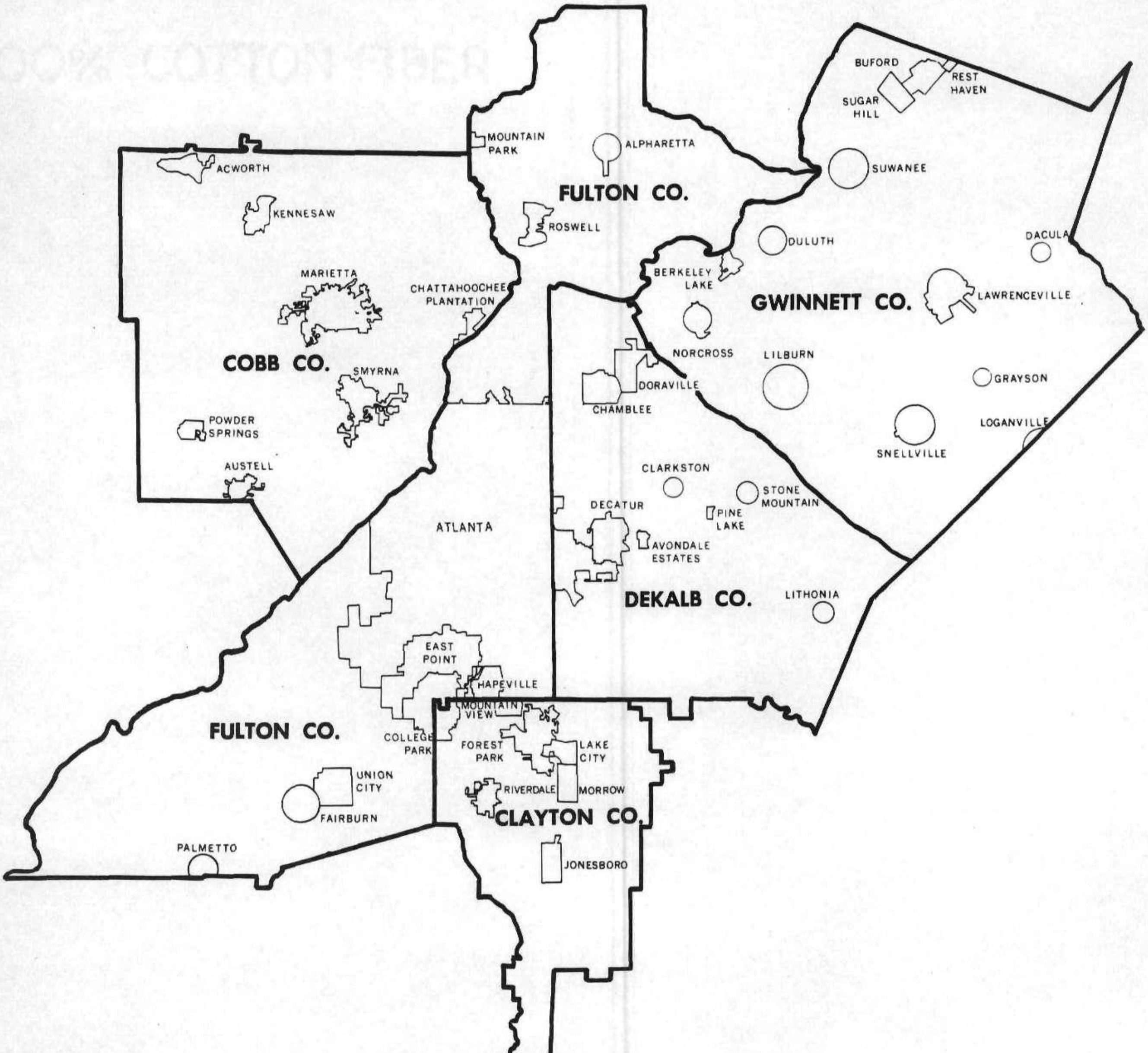

Figure 2. Atlanta Region Metropolitan Planning District.

Information about the number of employees, floor areas and distance from the central business district were obtained from the employer of each work center. This information is summarized in Table 1.

Information about employee social and economic, and travel characteristics were collected using a mail survey. This survey was done by distributing a return prepaid postage envelope to all employees of each of the 20 work centers. A copy of the questionnaire envelope is shown in Appendix 1. This questionnaire was carefully designed and submitted to criticism from several people of different disciplines, including city planners, social scientists, engineers and government officials. The questions asked are objective in nature and are presented to the employee in a simple form that can be easily and quickly answered. The information which these questions provide are summarized and tabulated in Table 2.

Coding of Data

Before coding the variables from the returned questionnaires of each of the 20 work centers, it was necessary to screen these questionnaires into 48 possible groups as listed in Table 3. Within each group the variables were quantified, coded and then punched on computer cards.

The screening of the questionnaires into 48 possible groups was done because the variables: sex, race, marital status and mode of travel cannot be quantified in a scalable manner, thus cannot be analyzed with the remaining 13 orderable variables (54).

Within each of the 48 groups, the orderable 13 variables were quantified and coded easily with the exception of the two variables "occupation or profession", and "education".

Table 1. Information About Employer

Employer Variables
Number of employees
Average rate of absenteeism
Floor area
Ground area
Number of floors
Parking area
Distance from central business district
Type of work activity
Assessed value

Table 2. Information About Employee

Non-Quantifiable Variables	Quantifiable Variables
Race	Age
Sex	Number of children
Marital status	Occupation or profession
Mode of travel	Educational level
	Number of years at work
	Home value
	Rent
	Lot size
	Distance home to work
	Travel time
	Personal income
	Family income
	Car ownership

Table 3. Possible Variables Groupings

Group Number	Group Description			
1	White	Male	Single	Drive to work
2	White	Male	Single	Ride bus
3	White	Male	Single	Walk
4	White	Male	Single	Car pool
5	White	Male	Married	Drive to work
6	White	Male	Married	Ride bus
7	White	Male	Married	Walk
8	White	Male	Married	Car pool
9	White	Male	Widowed/Divorced	Drive to work
10	White	Male	Widowed/Divorced	Ride bus
11	White	Male	Widowed/Divorced	Walk
12	White	Male	Widowed/Divorced	Car pool
13	White	Female	Single	Drive to work
14	White	Female	Single	Ride bus
15	White	Female	Single	Walk
16	White	Female	Single	Car pool
17	White	Female	Married	Drive to work
18	White	Female	Married	Ride bus
19	White	Female	Married	Walk
20	White	Female	Married	Car pool
21	White	Female	Widowed/Divorced	Drive to work
22	White	Female	Widowed/Divorced	Ride bus
23	White	Female	Widowed/Divorced	Walk
24	White	Female	Widowed/Divorced	Car pool
25	Non-white	Male	Single	Drive to work
26	Non-white	Male	Single	Ride bus
27	Non-white	Male	Single	Walk
28	Non-white	Male	Single	Car pool
29	Non-white	Male	Married	Drive to work
30	Non-white	Male	Married	Ride bus
31	Non-white	Male	Married	Walk
32	Non-white	Male	Married	Car pool
33	Non-white	Male	Widowed/Divorced	Drive to work
34	Non-white	Male	Widowed/Divorced	Ride bus
35	Non-white	Male	Widowed/Divorced	Walk
36	Non-white	Male	Widowed/Divorced	Car pool
37	Non-white	Female	Single	Drive to work
38	Non-white	Female	Single	Ride bus
39	Non-white	Female	Single	Walk
40	Non-white	Female	Single	Car pool
41	Non-white	Female	Married	Drive to work
42	Non-white	Female	Married	Ride bus
43	Non-white	Female	Married	Walk
44	Non-white	Female	Married	Car pool
45	Non-white	Female	Widowed/Divorced	Drive to work
46	Non-white	Female	Widowed/Divorced	Ride bus
47	Non-white	Female	Widowed/Divorced	Walk
48	Non-white	Female	Widowed/Divorced	Car pool

The variable "education" was quantified using the number of years the person spends acquiring education, to represent his educational level.

The variable "occupation or profession" was quantified using utility rating techniques. Several rating techniques were examined, and the one chosen was the North-Hatt occupational scaling method (55). The North-Hatt occupational scaling method was performed in the years 1947 and 1963, based on interviews with a national sample of raters. The resulting scales for the above-mentioned years, even though separated by a 16 year period were not significantly different. This invariance of the scales obtained from the North-Hatt method, implies a stability of this scaling over time (56). However, the values on the above scales could not be used without a subjective decision of the analyst in scaling the occupations of this investigation, because of the differences in the stratifications of the occupations of this investigation and the ones of the North-Hatt study. Therefore, to eliminate this subjective decision that may perturb the scalability of the North-Hatt scale, a new scale was obtained specifically for this investigation using the North-Hatt scaling method rather than the North-Hatt scale.

The North-Hatt scaling method started by choosing a jury of 10 judges to rate the 271 different occupations related to this study. These judges were chosen from different disciplines, backgrounds, race and sex, and such that they have a good knowledge of the different occupations (57). A brief description of these judges is shown in Table 29 of Appendix 2.

Each judge was given a list of the 271 occupations and a scale marked in units continuously from five to one. A rating of one indicates that this occupation has a "poor standing" and a rating of five indicates that this occupation has an "excellent standing".

The rating assigned to occupation α by judge β is represented by $V_{\alpha\beta}$, and the utility value, U_α, for occupation α is determined as follows:

$$V_\alpha = \sum_{\beta=1}^{10} V_{\alpha\beta} \qquad \alpha = 1,2,\ldots,271 \qquad [2]$$

and

$$U_\alpha = \frac{V_\alpha}{\sum_{\alpha=1}^{271} V_\alpha} \qquad \alpha = 1, 2, \ldots, 271 \qquad [3]$$

The details of the above method and the resulting occupational scale used in this investigation are described in Tables 30 and 31 of Appendix 2.

Method of Analysis

The method of analysis used in this investigation was predicated by the nature of the data collected and the objectives of the study.

The collected data are statistical in nature and are not only multivariable but also multivariate. That is to say, the variables collected are random variables, which in statistical terminology are defined as variates. Mathematically any of these variates can be expressed as follows:

$$X_i = x_i + e_i$$

where:

X_i = the i^{th} observed variate,

x_i = the i^{th} true variable, and

e_i = the stochastic or random error associated with the i^{th} variate (58), (59).

The random error associated with more than one variable, plus the fact that these variates are interdependent, brings the problem in the realm of multivariate statistics, which is defined as that branch of statistical analysis that is concerned with the relationships of sets of dependent variates (60).

Two subfields of multivariate statistical analysis were chosen to achieve the objectives of this investigation: 1) factor analysis and, 2) component analysis. These two techniques are distinct one from the other, even though in some practical problems this distinction is not clear (61). So in order to prevent any confusion, a brief description of these techniques is presented in the following paragraphs, also a flow chart summarizing the steps involved in this analysis is shown in Figure 3.

<u>Factor Analysis</u>

Factor analysis is the first multivariate statistical technique used in this investigation. This technique was developed primarily by psychologists "to provide mathematical models for the explanation of psychological theories of human ability and behavior" (62).

Factor analysis has two main objectives. The first is to analyze the distinct factors at work among the observed variables and to determine the degree of association between these variables. The second objective is to group the observed variables together in ways which

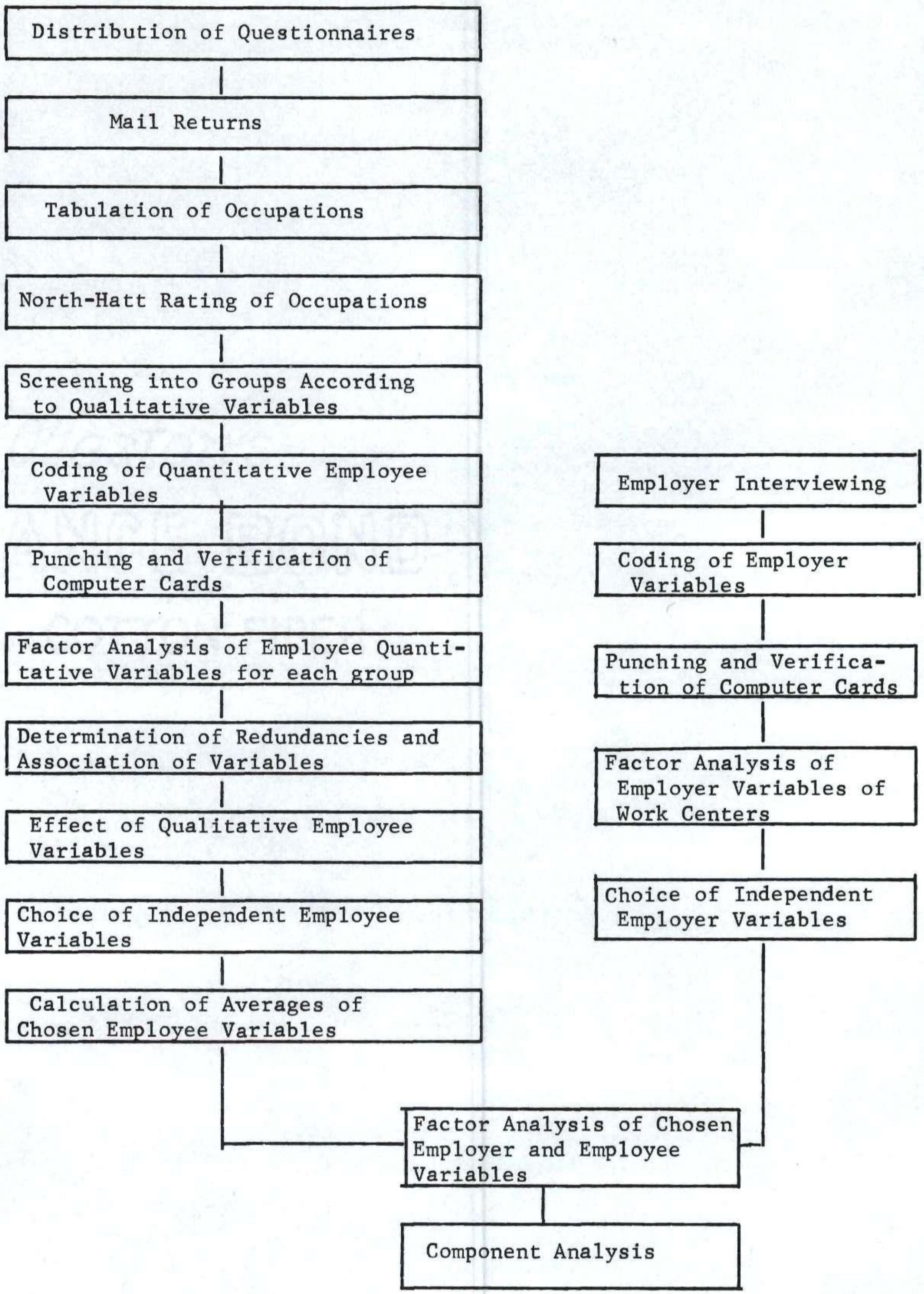

Figure 3. Flow Chart of Data Analysis

permit one to synthesize new entities called factors (63). These objectives are achieved mathematically in two operations: 1) factoring, and 2) rotation of reference frame.

Factoring is the operation that groups the observed data into common and unique factors. The common factors are those which appear in more than one observed variable, and conversely a unique factor appears only in a specific observed variable. This factoring operation is expressed mathematically by the following model, called factor pattern:

$$X_{ij} = \sum_{k=1}^{m} b_{ik} \quad f_{kj} + u_i \, s_{ij} + c_i e_{ij} \qquad [4]$$

where:

X_{ij} = the i^{th} observed variable on the j^{th} individual,

b_{ik} = the i^{th} factor loading of the k^{th} common factor,

f_{kj} = the k^{th} common factor relating to the j^{th} individual,

s_{ij} = the i^{th} unique factor corresponding to the i^{th} observed variable and relating to the j^{th} individual,

u_i = the weight of the i^{th} unique factor,

m = number of common factors,

e_{ij} = error term of the i^{th} observed variable relating to the j^{th} individual, and,

c_i = the weight of the i^{th} error term.

The common and unique factors, and the error terms of the factor pattern model are considered to be all independent inter se (64).

The factoring operation starts by standardizing the p observed variables describing each of the n observed individuals, to have zero means and unit variances; thus making them dimensionless. This standardization results in the following relationship:

$$\sum_{k=1}^{m} b^2_{ik} + u^2_i + c^2_i = 1, \qquad [5]$$

where the first term, $\sum_{k=1}^{m} b^2_{ik} = h^2_i$, is called the communality of the observed variable x_i, i.e. that portion of the total variance of variable x_i that can be explained by the m common factors. The second term, u^2_i, is called the specificity of the observed variable x_i, i.e. that portion of the total variance of variable x_i that is not shared with any other observed variable. The third term, c^2_i is called the unreliability of the observed variable x_i, i.e. the error variance portion associated with variable x_i (65).

The factoring operation proceeds to determine the common factors of the factor pattern model ignoring the non-communalities. This assumption will result in a rather subjective analysis where the relative values of the factor loadings and their signs will be of prime importance (66). The determination of these common factors is obtained using the principal component analysis explained in the next section of this chapter (67).

Rotation of reference frame is the next operation of the factor analysis technique. This operation rotates the axes of reference to facilitate the interpretation of the factor solution obtained above. This rotation of axes was accomplished by the varimax method of rotation which is defined and explained in Appendix 4.

The computer program used in this technique presents as output, all the major rotation iterations; thus the analyst can examine the

the interactions between the observed variables at each step, and a better understanding of the factors at work can be obtained. Table 4, shows an example of the output of the varimax rotation matrix. This varimax factor matrix is for the group: Female-Married-Car pool. This matrix consists of seven factors which explain 92.1 percent of the total variance of the 13 original variables. The amount of variance explained by each factor is represented by its corresponding eigenvalue. The total amount of variance explained (92.1 percent) by the seven factors is obtained by summing the eigenvalues and dividing this sum by the number of original variables. This summation is possible because the factors are orthogonal or independent one from the other . The elements of the varimax factor matrix, called factor loadings, are the expressions of the contribution of each factor in explaining the variables. These factor loadings are in a sense the correlation coefficients between the factor and the variable, and their values vary between + 1 and - 1. In this investigation, these factor loadings were multiplied by 100 for clarity of presentation. The closer the factor loading is to $\pm$ 100, the stronger is the degree of association between the factor and the variable. In this study, values of factor loadings above $\pm$ 40 are considered to be significant and are therefore placed between brackets. Thus, significant factor loadings can be used to identify a variable or variables within a given factor. For example, factor 1 is highly associated with the variables home value, rent and lot size, which imply that two of these variables are redundant, and therefore one can be deleted. The usual criterion used in deciding which variable to be retained is the factor loading. This criterion should be supplemented by other criteria

Table 4. Varimax Factor Matrix Female Married Car Pool Group of Work Center H. (92.1 per cent)

	FACTOR						
Variable	1	2	3	4	5	6	7
Age	35.3	3.7	(71.5)	-16.5	(40.2)	-31.3	12.8
Children	12.1	16.0	6.1	7.7	(93.8)	-19.0	13.4
Occupation	-6.3	-13.7	(90.2)	17.5	4.6	- 4.6	- 2.8
Education	-15.9	17.5	- 1.8	(95.1)	5.6	- 7.6	- 1.3
Years at Work	17.6	-28.0	(81.3)	- 21.4	-11.1	-26.0	0.7
Home Value	(87.8)	0.4	15.9	- 2.9	20.0	-25.5	14.5
Rent	(-91.1)	27.1	- 1.6	14.0	- 4.5	2.0	- 5.7
Lot size	(92.8)	-10.2	7.6	- 7.1	- 0.8	-18.2	17.9
Cars	33.0	-27.0	0.5	- 1.6	17.4	-15.1	(86.6)
Income	18.2	-41.0	34.9	23.6	17.4	(-69.8)	-5.8
Family Income	24.7	0.0	17.6	- 0.9	15.7	(-87.7)	18.9
Time of Travel	9.2	(-92.8)	13.5	- 8.8	- 5.5	- 8.1	17.7
Distance of Travel	18.9	(-90.6)	17.0	-14.1	-14.4	- 6.9	7.2
Eigenvalues	5.06	2.10	1.96	1.10	0.81	0.59	0.36

such as the ease, consistency and economy with which a variable is measured or predicted. Conversely, factor 7 is only strongly associated with the variable car ownership. This single variable factor indicates that car ownership is relatively independent from the other variables, and therefore should be retained in collecting the data.

Component Analysis

Component analysis is the second multivariate statistical technique used in this investigation. This technique consists of two main steps: 1) principal component analysis, and 2) component regression analysis.

Principal component analysis is that operation which generates, from the observed interrelated variables, a new set of variables called components, that have the property of being statistically independent (orthogonal). This operation starts by standardizing the p variables, describing each of the n observed individuals, to have zero means and unit variances; thus making them dimensionless. Then principal component analysis minimizes the sum of squares of the distances from the n points of the p-dimensional space, where each of the n individuals is represented by a point in the p-dimensional space. This sum of squares of the distances is expressed mathematically by:

$$S = \sum_{j=1}^{n} \left[\sum_{i=1}^{p} X^2_{ij} - \sum_{i=1}^{p} \ell_i X_{ij} \right] \qquad [6]$$

where:

X_{ij} = standardized variable i of the j^{th} individual,

ℓ_i = direction cosine of the component to be determined with the axis X_i,

p = number of variables observed, and

n = number of individuals.

The sum of squares, S, is minimum when the following condition is satisfied (68):

$$(\underline{r} - E\,\underline{I})\,\underline{\ell} = \underline{0} \qquad [7]$$

where:

$\underline{\ell}$ = vector of direction cosines of the components to be determined with the axis of coordinates,

$\underline{I}$ = identity matrix,

E = Lagrange multiplier associated with the constraint and

$\underline{r}$ = matrix of simple correlation coefficients of the observed variables , where:

the simple correlation coefficient of any two variables x_1 and x_2 may be computed from:

$$r_{x_1x_2} = \frac{\sum_{j=1}^{n} (x_{1j} - \overline{x}_1)(x_{2j} - \overline{x}_2)}{\sqrt{\sum_{j=1}^{n} (x_{1j} - \overline{x}_1)^2 \sum_{j=1}^{n} (x_{2j} - \overline{x}_2)^2}} \qquad [8]$$

where:

$\overline{x}_1$ = mean of observed variable x_1,

$\overline{x}_2$ = mean of observed variable x_2, and

the remaining terms have the same definition as before.

Equation [7] is a homogeneous equation, and its solution will result in a set of eigenvalues E, and their corresponding set of eigenvectors, $\underline{C}$, as defined and explained in Appendix 3. The eigenvectors obtained are the orthogonal components, and the eigenvalues are their respective variances. These eigenvalues are determined in a descending order of magnitude so far as the information is concerned. That is to say, the first component obtained explains the largest portion of the variance. The components obtained can be expressed as a linear combination of the original so-called independent variables, and conversely, an original variable can be expressed as a linear combination of the components.

Component regression analysis is that operation which regresses the dependent variable, y chosen from the observed variables, on the orthogonal components, $\underline{C}$, generated from principal component analysis. This regression analysis is a stepwise operation which brings to the regression equation one component after the other, starting with the first component. The regression equation has the form:

$$y = a_1C_1 + a_2C_2 + a_3C_3 + \ldots. + a_pC_p \qquad [9]$$

where:

$a_1, a_2, \ldots, a_p$ = coefficients of the components of the model,

$C_1, C_2, \ldots, C_p$ = components, and

y = dependent variable.

The coefficients of the equation are determined as in ordinary multiple regression analysis from the relation:

$$a_i = \frac{\ell_{1i}r_{x1}y + \ell_{2i}r_{x2}y + \ldots \ell_{pi}r_{xp}y}{E_i} \qquad [10]$$

where the terms have the same definition as before (69). The above coefficients are standardized and they represent the actual contribution of each independent variable on the dependent variable (70).

The computer program used in this technique enables the analyst to examine the structure of the components in addition to the other statistical tests performed at each step of regression. This examination of structure helps to choose the most logical and rational mathematical model and not necessarily the one that gives the best fit (71). The output of the analysis is the components matrix with their respective eigenvalues, and the component regression model with the statistical tests. The component matrix is similar to the factor analysis matrix illustrated in Table 4. This table has only as variables the independent variables, and the elements of the matrix are the direction cosines relating the independent variables to the respective components. These direction cosines elements have similar interpretation to the factor loadings of the factor analysis matrix, and in addition are exact mathematical expressions. The component regression model output shows the model with the coefficients in the standardized and scaled forms, and the statistical tests on the model.

Statistical Measures. The statistical measures of importance used in this component analysis are: 1) test of significance of the principal components, and 2) test and measures of importance of the component regression model and of its coefficients.

The test of significance of the principal components is called Bartlett's test (72), which determines the significant components to be used in the component regression analysis. This test starts by testing the significance of the entire structure first and then tests the significance of the residual structure obtained by extracting one component at a time. The test of significance of the entire structure is conducted by computing the statistic:

$$Q = -[(n-1) - \frac{1}{6}(2p + 5)] \log /\underline{r}/ \qquad [11]$$

which follows the chi-square distribution with $\frac{1}{2}$ p(p-1) degree of freedom where:

$|r|$ = determinant of the matrix of the correlation coefficients of the observed variables,

p = number of variables observed, and

n = number of individuals or observations.

The test procedure is a likelihood ratio test. This test depends on a large sample size and on the independent variables being normally distributed. The interpretation of a highly significant test statistic implies the significance of the first component.

The test of significance of the remaining structure after extracting k components is performed by computing the statistic:

$$Q = -(n-p-\frac{1}{2}) \log \left| \underline{r}_{p-k} \right| \qquad [12]$$

which follows the chi-square distribution with $\frac{1}{2}$ (p-k) (p-k-1) degrees of freedom and such that,

$$\underline{r}_{p-k} = \frac{\quad}{E_1 \cdot E_2 \ldots, E_k \left(\frac{p - E_1 \cdot E_2 \ldots, E_k}{p-k} \right)}^{p-k}$$

where:

k = number of components previously accepted as significant,

E_i = eigenvalue associated with the i^{th} component, and

p, n, and $\underline{r}$ are defined previously.

This statistic is distributed as a chi-square for the same reasons as is the statistic of the entire structure.

The interpretation of a highly significant test statistic after extracting the k^{th} component implies that the respective component is significant and should be considered in the analysis.

The test and measures of importance of the component regression model and of its coefficients are essentially the same as those used in ordinary multiple linear regression analysis. The F-ratio test is basically a test of significance of the model. This ratio indicates the amount of variation explained by the model compared with the residual unexplained variation. The calculations of the F-ratio are the same as the ones of ordinary regression which involve an analysis of variance and forming the ratio of the mean square of regression to the mean square of error.

The measures of importance used on the component regression model and on its coefficients are: 1) coefficient of multiple determination, 2) standardized regression coefficients, 3) standard deviation of the error, 4) standard deviation of the estimate, and 5) efficiency of the model.

The coefficient of multiple determination, R^2, measures the proportion of variation in the dependent variable which is explained by, or associated with, differences in the independent component or components. This coefficient is a measure of goodness of fit of the component regression model and it is calculated by the relation:

$$R_i^2 = E_i a_i^2 \qquad [13]$$

where:

R_i^2 = coefficient of determination of the component regression model when only the i^{th} principal component is in the model,

E_i = eigenvalue of the i^{th} principal component, and

a_i = coefficient of the i^{th} principal component of the model.

It is worth noting that when another component enters the regression model, the coefficient of determination will be the sum of the coefficients of determination due to each component. This addition is justified because of the orthogonality of the components.

The standardized regression coefficients of the model represent an estimate of the independent contributions of their respective variables as far as numerical value and sign are concerned.

The standard deviation of the error and the standard deviation of the estimate are the respective measures of accuracy of the error and the dependent variable.

The efficiency of the component regression model is measured by:

$$\frac{\text{standard deviation of error-standard deviation of dependent variable}}{\text{standard deviation of dependent variable}}$$

It is worth noting that the above multivariate statistical techniques do not assume multinormal frequency distribution of their variables; however, the tests of significance are based on such assumption (73). Also it is worth mentioning, that the frequency distribution curves were plotted for the different observed variables and their shapes were not visually far from the normal density function.

CHAPTER IV

ANALYSIS OF EMPLOYEE CHARACTERISTICS

In this chapter, the characteristics of the employees of the 20 work centers surveyed are analyzed to determine the interrelationship between these characteristics. These work centers are identified by alphabetical letters because of the confidential nature of the data collected. Table 5 describes briefly the type of work activity and the number of employees of each of these centers. The analysis of the employee characteristics was done by using factor analysis on the quantifiable variables and then the effect of the qualitative variables was analyzed by isolating each qualitative variable one at a time. The qualitative variables analyzed are: sex, marital status and mode of travel. The qualitative variable race was not investigated because of the lack of sufficient number of non-white respondants to form a group.

The groups that had a significant number of returns are the following:

1. Male, single, drive to work
2. Female, single, drive to work
3. Male, married, ride bus
4. Male, married, drive to work
5. Male, married, car pool
6. Female, married, drive to work
7. Female, married, car pool.

Table 5. Description of Work Centers

Work Center	Type of Work Activity	Number of Employees
A	Education	1,037
B	Public	744
C	Public	650
D	Public	1,100
E	Office	1,000
F	Office	1,300
G	Office, Manufacturing	1,350
H	Office	2,203
I	Office	4,500
J	Office	917
K	Public	500
L	Office	1,059
M	Office	200
N	Office	200
O	Office, Manufacturing	800
P	Office, Manufacturing	1,400
Q	Office, Manufacturing	398
R	Office, Manufacturing	1,300
S	Office, Manufacturing	1,053
T	Office, Manufacturing	1,025

Several work centers appeared within each of the above groups whose employees quantitative and qualitative varaibles were analyzed.

Analysis of Quantitative Variables

The analysis of the employee quantitative variables was done for each of the above seven groups separately. This analysis by groups was necessary in order to isolate the effects of the qualitative variables.

A total of 42 factor analaysis runs were performed, and the resulting varimax factor matrices are tabulated in Appendix 5. A minimum of 83 percent of the total variance of the variables was considered acceptable to stop the varimax rotation. The actual percentage of the total variance explained by the factors is shown between parenthesis on each varimax factor matrix table.

Male Single Drive to Work Group

Four work centers had sufficient number of returns belonging to this group. These work centers are: H, G, B and L. Tables 24 through 27, of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrix of work center H is analyzed to illustrate the determination of the degree of association and the interrelationships between the employee quantitative variables. Table 6 shows this varimax factor matrix.

Because the marital status of the employees of this group is single, the variable: number of children, was not included. The remaining variables that were analyzed are 12 which collapsed to six factors. These six factors explained 88.5 percent of the total variance of the 12 variables. As indicated by the eigenvalues, the first factor explained the largest percentage of the total variance. The six factors

Table 6. Varimax Factor Matrix Male Single Drive to Work Group of Work Center H. (88.5 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	(68.7)	(44.5)	11.1	-18.3	10.7	-12.4
Occupation	(89.0)	5.4	-2.7	24.8	-3.9	7.8
Education	28.0	0.5	-3.2	(85.9)	9.8	6.0
Years at work	(51.0)	35.3	2.1	(-47.3)	32.6	16.1
Home value	16.4	(94.6)	1.5	-2.8	17.5	-8.3
Rent	16.1	-13.5	-3.2	3.0	-4.9	(96.6)
Lot size	7.1	(95.6)	16.9	-0.3	3.1	-7.3
Cars	0.2	15.6	-7.9	5.8	(95.7)	-5.5
Income	(95.6)	5.3	-11.6	10.0	0.7	11.9
Family income	(95.6)	5.3	-11.6	10.0	0.7	11.9
Time of travel	-0.1	9.3	(94.7)	7.9	-3.5	3.7
Distance of travel	-13.9	8.6	(92.6)	-13.2	-5.0	-8.2
Eigenvalues	4.00	2.49	1.58	1.00	0.84	0.72

are orthogonal one with the other, and therefore each represents an independent piece of information of the surveyed 12 variables.

Factor one has high factor loadings with the five variables: age, occupation, years at work, income, and family income. This means that this factor has the above five variables as significant, and that they are interrelated. Therefore, one of these five significant variables could be used to provide the information that factor one explains.

Factor two has high factor loadings with the three variables: age, home value and lot size. This factor shows the strong association of home value and lot size with the age of the respondant. Again one of these three variables could be used to provide the information of this factor and the two remaining will be redundant.

Factor three is a factor that gives information about travel because of the high degree of association of the two variables time and distance of travel with it. This means that these two variables are relatively independent from the other employee variables.

Factor four is a factor that is highly associated with the two variables: education level and years at work, and relatively independent from the other variables.

Factor five is a one variable factor. This variable is the number of cars in the family. This means that this variable is not related to the others and is necessary in explaining the information that this factor provides.

Factor six is also a one variable factor and this variable is the rent and must be included to provide the information that this factor provides.

Doing the same analysis with the three other work centers G, B and L from their respective varimax factor matrices will determine the significant variables strongly associated with the orthogonal factors. These significant variables of the male, single, drive to work group are summarized in Table 7. The numbers within this table refer to the number of work centers belonging to this group and in which a certain variable was significantly associated with another variable under the same factor. The variables are indexed for convenience and clarity of presentation. The number 3 in row 4 and column 6 shows that the variable age was significantly related to the variable income in three of work centers belonging to the male, single, drive to work group. Conversely, the number 3 in row 3 and column 3 indicates that the variable rent appeared independent in three out of the four work centers belonging to this group.

Table 7 shows that the variables time and distance of travel form an independent factor from the remaining variables, and that they are strongly related one with the other which implies that one of them could be deleted. Conversely, the table shows a large scatter between the variables of the second category: income, family income, age, years at work, education and occupation. These variables are strongly interrelated and considerable duplication exists in collecting them all. A third category of variables is formed of the variables home value, lot size, age and education which are also highly related one with the other with significant redundancies. The fourth category shows a strong association between family income and the number of cars in the family. Finally, the fifth category is a single variable factor containing the

Table 7. Summary of Variable Relationships of Male Single Drive to Work Group. (Four Work Centers)

Index	Variable	Variable 1	2	3	4	5	6	7	8	9	10	11	12
1	Home value*		3	1	2	1				2			
2	Lot size	3		1	2	1							
3	Rent	1	1	3							1		
4	Age	2	2			4	3	1	2	2			
5	Years at work	1	1		4		3	1	1	2			
6	Income				3	3		2	3	3			
7	Family income				1	1	2		1	1	2		
8	Occupation				2	1	3	1		3	1		
9	Education	2				2	3	1	3		1		
10	Number of cars			1				2	1	1			
11	Time of travel												4
12	Distance of travel											4	

* This variable appeared only in 3 out of 4 work centers.

variable rent which showed to be independent in this group of male, single, drive to work.

In summary of this group of male, single, drive to work, there are five sets of employee variables:

1. Time and distance of travel
2. Income, family income, years at work, occupation and education
3. Home value, lot size, age, and education
4. Cars and family income
5. Rent

Female Single Drive to Work Group

Four work centers had sufficient number of returns belonging to this group. These work centers are: H, G, I, and D. Tables 28 through 31 of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrices of these four work centers were analyzed as was illustrated in the previous group. The significant variables of this group were summarized in Table 8. This table shows that the variables time and distance of travel form an independent factor from the other variables and that these two variables are strongly interrelated. The table also showed a second category of variables formed of home value, rent and lot size which were strongly interrelated to each other and fairly associated with the variables of age and years at work. Conversely a third category consists of the variables: family income, rent and number of cars which were strongly associated. The fourth category related strongly income to the variables: age, years at work and occupation. The fifth category is a single variable factor containing the variable education.

Table 8. Summary of Variable Relationships of Female Drive to Work Group. (Four Work Centers)

Index	Variable	1	2	3	4	5	6	7	8	9	10	11	12
1	Home value *		3	3	1	2							
2	Lot size*	3		3	1	2							
3	Rent	3	3	2	1	2		3			3		
4	Age	1	1	1		4	2			1			
5	Years at work	2	2	2	4		2			2			
6	Income				2	2		1	4	1			
7	Family income			3			1		1		3		
8	Occupation						4	1					
9	Education				1	2	1			2			
10	Number of cars			3				3					
11	Time of travel												4
12	Distance of travel											4	

* This variable appeared only in 3 out of 4 work centers.

In summary of this group of female, single, drive to work, there are five sets of employee variables:

1. Time and distance of travel
2. Income, age, years at work, and occupation
3. Home value, lot size, age, rent and years at work
4. Cars, family income, and rent
5. Education

Male Married Ride Bus Group

Two work centers had sufficient number of returns belonging to this group. These work centers are: E and L. Tables 32 and 33 of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrices of these two work centers were analyzed and summarized as shown in Table 9. This table indicates that the variables time and distance of travel form an independent factor from the other variables and that they are strongly interrelated. It is also seen that the variables: home value, rent and lot size formed a second category of variables. However, this second category was strongly associated with the family income variable. The third category of variables is formed of the strongly interrelated variables: age, years at work, income and family income. The fourth category of variables included the number of cars which appeared as a single variable factor that is independent from the other variables. The fifth category is also a single variable factor formed of the variable: number of children which also appeared to be independent from the other variables. A six category of variables that did not show strong association between themselves is formed of the variables: occupation and education. These two variables

Table 9. Summary of Variable Relationships of Male Married Ride Bus Group. (Two Work Centers)

Index	Variable	Variable 1	2	3	4	5	6	7	8	9	10	11	12	13
1	Home value		2	2				2						
2	Lot size	2		2				2						
3	Rent	2	2					2						
4	Age					2	2	2						
5	Years at work				2		2	2						
6	Income				2	2		2	1	1				
7	Family income	2	2	2	1	2	2		1	1				
8	Occupation						1	1	1	1				
9	Education						1	1	1					1
10	Number of cars										2			
11	Number of children											2		
12	Time of travel													2
13	Distance of travel												2	

showed only a fair association with the variables of income and family income.

In summary of this group of male, married, ride bus, there are six sets of employee variables:

1. Time and distance of travel
2. Home value, rent, lot size, and family income
3. Age, years at work, income and family income
4. Number of cars
5. Number of children
6. Occupation, education, income and family income

Male Married Drive to Work Group

Fifteen work centers had sufficient number of returns belonging to this group. These work centers are: B, C, D, E, F, G, H, I, J, K, L, M, N, O, A. Tables 34 through 48 of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrices of these 15 work centers were analyzed and summarized as shown in Table 10. This table indicates that the two variables time and distance of travel for an independent factor from the other variables and that they are very strongly related one to the other. A second category of variables is formed of the variables: home value, rent, and lot size. This second category seemed to be relatively independent from the other employee variables. The third category is a one variable factor formed of the variable: number of cars, which is independent from the other variables. The fourth category is also a single variable factor having the variable: number of children to be independent from the remaining variables. The fifth category is formed

Table 10. Summary of Variable Relationships of Male Married Drive to Work Group. (15 Work Centers)

Index	Variable	Variable 1	2	3	4	5	6	7	8	9	10	11	12	13
1	Home value		14	15	3		4	4	4	2		1		
2	Lot size	14	1	14	1							1		
3	Rent	15	14		1							1		
4	Age	3	1	1	1	10	5	6	2			1		
5	Years at work				10	3	3	3						
6	Income	4			5	3		14	11	7				
7	Family income	4			6	3	14	1	11	7	2			
8	Occupation*	4			2		11	11	2	7		1		
9	Education*	2					7	7	7	5				
10	Number of cars							2			12	1		
11	Number of children	1	1	1	1				1		1	13		
12	Time of travel													15
13	Distance of travel												15	

* This variable appeared only in 14 out of 15 work centers.

of the variables: income, family income, occupation and education. These variables are strongly interrelated. A sixth category is formed of the variables: age and years at work which are strongly associated with each other and are fairly related to the variables: income and family income.

In summary of this group of male, married, drive to work, there are six sets of employee variables:

1. Time and distance of travel
2. Home value, rent, and lot size
3. Number of cars
4. Number of children
5. Income, family income, occupation and education
6. Age, years at work, income and family income

Male Married Car Pool Group

Four work centers had sufficient number of returns belonging to this group. These work centers are: L, H, E, and B. Tables 49 through 52 of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrices of these four work centers were analyzed and summarized in Table 11. This table shows that the two variables time and distance of travel are strongly interrelated and that they are associated with a single factor. This factor is also independent from the other variables and forms a separate piece of information. A second category of variables is formed of the three variables: home value, rent and lot size. This category is also independent from the other variables, and the three variables belonging to it, are strongly associated one with the other. The third category

Table 11. Summary of Variable Relationships of Male Married Car Pool Group. (Four Work Centers)

		Variable												
Index	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Home Value	2	2	4										
2	Lot size	2		2	1				1					
3	Rent	4	2											
4	Age		1			3	3	2	1					1
5	Years at work				3		4	3	2	1				
6	Income				3	4		4	2	1	1			1
7	Family income				2	3	4		3	1	2			1
8	Occupation		1			2	2	3				1		
9	Education					1	1	1		2				
10	Number of cars						1	2			2			
11	Number of children								1			3		
12	Time of travel													4
13	Distance of travel				1	1	1	1					4	

of variables is a single variable factor formed of the variable: number of children, which is independent of the other variables pertinent to the employee. The fourth category of variables includes a cluster of five variables: age, years at work, income, family income, education and occupation. These variables are strongly interrelated with each other and form a separate piece of information. A fifth category is formed of the variable: number of cars which appeared to be fairly associated with the variable: family income.

In summary of this group of male, married, car pool, there are five sets of employee variables:

1. Time and distance of travel
2. Home value, rent and lot size
3. Number of children
4. Family income, number of cars
5. Age, years at work, income, family income, occupation and education

Female Married Drive to Work Group

Nine work centers had sufficient number of returns belonging to this group. These work centers are: H, G, F, E, D, I, J, K, and B. Table 53 through 61 of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrices of these nine work centers were analyzed and summarized as shown in Table 12. This table shows the two variables time and distance of travel are very highly interrelated and that they are strongly associated with a single factor that is independent from the remaining employee variables. A second category of variables is formed of the three variables: home value, rent, and lot size.

Table 12. Summary of Variable Relationships of Female Married Drive to Work Group. (Nine Work Centers)

Index	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Home value		9	9	2	1								
2	Lot size	9		9	2	1								
3	Rent	9	9		2	1								
4	Age	2	2	2		7	4	1				4		
5	Years at work	1	1	1	7		5	1	2					
6	Income				4	5	1	5	7	2				
7	Family income				1	1	5	2	1	3	2			
8	Occupation					2	7	1		1	1			
9	Education						2	3	1	5	1			
10	Number of cars							2	1	1	7			
11	Number of children				4					1	4			
12	Time of travel													9
13	Distance												9	

This category is relatively independent from the other variables, and the three variables belonging to it are strongly associated one with the other. The table also showed a third category formed of a one variable factor. This variable is the number of cars which again appeared to be highly independent from the others. The fourth category of variables includes the variables: age, years at work, income, family income and occupation. These variables were interrelated with each other and are relatively independent from the remaining ones. The fifth category of variables includes the variable: number of children which showed in this group to be related to the variables: number of cars and age. The last category of variables had the variable education to be relatively independent from the others with the exception of some association with the variable family income.

In summary of this group of female, married, drive to work, there are six sets of employee variables:

1. Time and distance of travel
2. Home value, rent and lot size
3. Number of cars
4. Age, years at work, income, family income and occupation
5. Number of children, age, and number of cars
6. Education and family income

Female Married Car Pool Group

Four work centers had sufficient number of returns belonging to this group. These work centers are: L, I, E, and H. Tables 62 through 65 of Appendix 5 are the results of their factor analysis runs.

The varimax factor matrices of these four work centers were analyzed and summarized as shown in Table 13. This table indicates that the two variables time and distance of travel are very strongly related to each other and that they belong to the same factor which is independent from the other variables. A second category of variables is formed of the variables: home value, rent and lot size. These variables showed a strong interrelationship and they appeared to be relatively independent from the remaining variables with the exception of some fair association with the two variables: age and years at work. The third category is a single variable factor having the variable: education as independent from the other variables. Similarly, a fourth category consists of a single variable factor having the variable: number of cars as independent from the others. The fifth category of variables is formed of the variables: age, years at work, income, family income, and occupation. These variables were interrelated with each other. A last category of variables showed that the number of children in this group to be related to the variable age.

In summary of this group of female, married, car pool, there are six sets of employee variables:

1. Time and distance of travel
2. Home value, rent and lot size
3. Education
4. Number of cars
5. Age, years at work, income, family income and occupation
6. Number of children and age

Table 13. Summary of Variable Relationships of Female Married Car Pool Group. (Four Work Centers)

Index	Variable	Variable 1	2	3	4	5	6	7	8	9	10	11	12	13
1	Home value		4	4	2	2	1	1						
2	Lot size	4		4										
3	Rent	4	4											
4	Age	2				4	2	1	1			2		
5	Years at work	2			4		3	2	2					
6	Income	1			2	3		3	1	1			1	1
7	Family income	1			1	2	3		1		1	1		
8	Occupation				1	2	1	1	1					
9	Education						1			3				
10	Number of cars							1			3			
11	Number of children				2			1				1		
12	Time of travel													4
13	Distance of travel												4	

Effect of Qualitative Variables

The effects of the qualitative variables on the quantitative ones were determined by isolating each qualitative variable at a time and analyzing the factor analysis summaries of each group. The qualitative variables whose effects were considered are: sex, marital status, and mode of travel.

Effect of Sex Variable

The effect of the sex variable on the degree of association between the employee quantitative variables was determined by comparing the factor analysis results of those groups having the same marital status and mode of travel variables. The first set of groups that were compared is formed of the two groups: 1) male, single, drive to work, and 2) female, single, drive to work. The results of their factor analysis summaries are shown in Tables 7 and 8 respectively. In both groups, the variables time and distance of travel were strongly associated with each other under a single factor regardless of their sex characteristic. Similarly, the variables: income, age, years at work and occupation were strongly associated between themselves under one factor regardless of the sex variable. However, the variables: home value, lot size and age were associated with the variables: rent and years at work for the female group and with the education variable for the male group. The tables also showed that the variables: number of cars and family income had a strong association in both sexes, moreover, in the female group, the rent variable was also associated with them.

The second set of groups that were compared is formed of the two groups: 1) male, married, drive to work, and 2) female, married, drive to work. The results of their factor analysis summaries are shown in Tables 10 and 11 respectively. These tables showed that the variables time and distance of travel were strongly associated with each other under one factor regardless of the sex variable. Similarly, the variables home value,rent and lot size were associated under a single factor in both male and female groups. Also, the variables: tamily income, occupation, and education showed a strong association between themselves regardless of the sex variable. The comparison of the two groups also indicated that the number of cars variable appeared in both groups as a single variable factor independent from the other variables. Conversersely, the variable: number of children appeared also as a single variable factor for the male group and was associated with the variables: age and number of cars in the female group. Finally, the variables: age, years at work, income, and family income were also strongly associated under one factor regardless of the sex variable, with the exception of their additional association with the occupation variable in the female group.

The third set of groups that were compared is formed of the two groups: 1) male, married, car pool, and 2) female, married, car pool. The results of their factor analysis summaries are shown in Tables 11 and 13 respectively. These tables showed that the variables time and distance of travel were highly interrelated under a single factor regardless of the sex variable. Similarly, the variables: home value, lot size, and rent were strongly associated under one factor for both male and female groups. Conversely, the variables age, years at work, income, family income, and occupation were strongly associated between themselves in both sex groups with an additional association with the education variable for the male group. The tables also showed that the variable: number of cars appeared as a single variable factor in the female group, and was associated with the family income variable in the male group. Conversely, the number of children variable appeared as a single variable factor in the male group, and was associated with the age variable in the female group.

In summary, the qualitative variable sex affected the association between the quantitative variables: age, number of children, number of cars, home value, rent and lot size. Conversely, this sex variable had no effect on the association between the remaining employee quantitative variables.

Effect of Marital Status Variable

The effect of the marital status variable on the degree of association between the employee quantitative variables was determined by comparing the factor analysis results of those groups having the same sex and mode of travel variables. The first set of groups that were compared is formed of the two groups: 1) male, single, drive to work, and 2) male, married, drive to work. The results of their factor analysis summaries are shown in Tables 7 and 10 respectively. In both groups, the variables time and distance of travel were strongly interrelated and appeared as an independent factor regardless of the marital status variable. Similarly, the variables: income, family income, occupation and education were strongly associated between themselves regardless of martial status. The tables also showed that the variables: age and years at work were strongly related to the income and family income variables regardless of marital status. Conversely, the variable number of cars appeared as a single variable factor in the case of married status, while it was related to the family income variable in the single status group. Similarly, the variable rent appeared as a single variable factor for the single status group and was associated with the two variables: home value and lot size in the married status group.

The second set of groups that were compared is formed of the two groups: 1) female, single, drive to work, and 2) female, married, drive to work. The results of their factor analysis summaries are shown in Tables 8 and 12 respectively. These tables showed that the variables time and distance of travel were strongly associated with each other under one factor regardless of the marital status variable. Similarly, the variables: income, family income, and occupation were associated with the variables: age and years at work in both marital status groups. Conversely, the variables: home value, rent, and lot size were associated strongly between themselves and appeared as an independent factor in the case of the married status group, while they were also associated with the variables: age and years at work in the single status group. The tables also showed that the variable number of cars was associated with the variables: age and number of children in the married status group, and was associated with the variables: family income and rent in the single status group.

In summary, the qualitative variable marital status affected the association between the employee quantitative variables: age, years at work, rent, home value, lot size, number of cars, and family income. Conversely, this marital status variable had no effect on the association between the remaining employee quantitative variables.

Effect of Mode of Travel Variable

The effect of the mode of travel variable on the degree of association between the employee quantitative variables was determined by comparing the factor analysis results of those groups having the same sex and marital status variables. The first set of groups that were compared is formed of the three groups: 1) male, married, drive to work, 2) male, married, car pool, and 3) male, married, ride bus. The results of their factor analysis summaries are shown in Tables 10, 11 and 9 respectively. In the three groups of this set, the variables time and distance of travel were strongly interrelated and appeared as an independent factor regardless of the mode of travel variable. Similarly, the variables: age, years at work, income, family income, occupation and education were strongly associated between themselves regardless of the mode of travel variable. Conversely, the variables: home value, rent and lot size were strongly interrelated between themselves and appeared as an independent factor in both modes of travel: drive to work and car pool; however, they were associated with the variable family income in the ride bus mode of travel. The tables also showed that the variable number of cars appeared as a single variable factor in both ride bus and drive to work groups, while it was associated with the family income variable in the car pool group. Similarly, the variable number of children appeared as a single variable in both car pool and ride bus groups, while it was associated with the variables age and number of cars in the drive to work group.

The second set of groups that were compared is formed of the two groups: 1) female, married, drive to work, and 2) female, married, car pool. The results of their factor analysis summaries are shown in Tables 12 and 13 respectively. These tables showed that the variables time and distance of travel were strongly associated with each other under one factor regardless of the mode of travel variable. Similarly, the variables: home value, rent, and lot size were strongly associated between themselves and appeared as an independent factor regardless of the mode of travel. The tables also showed that the variables: age, years at work, income, family income, and occupation were strongly interrelated under a single factor regardless of the mode of travel. Conversely, the variable number of cars appeared as a single variable factor in the car pool group, while it was associated with the age and number of children variables in the drive to work group. Similarly, the variables education and family income were strongly associated under a single factor in the drive to work group and were not interrelated in the car pool group.

In summary, the qualitative variable mode of travel affected the association between the employee quantitative variables: home value, rent, lot size, family income, number of cars, number of children, age, and education. Conversely, this mode of travel variable had no effect on the association between the remaining employee quantitative variables.

Summary of Analysis of Employee Characteristics

In this summary of the analysis of the 13 employee connected variables of the 20 work centers surveyed in the Atlanta Metropolitan Area, the following points can be stated:

1. The 13 employee quantitative variables collapsed into a maximum of six factors explaining a minimum of 83 percent of the total variance of the variables in any of the 42 factor analysis runs. These six factors are:

(i) Travel Factor having the variables time and distance of travel strongly associated with it in all the groups analyzed. These variables were not affected by any of the qualitative variables: sex, marital status, and mode of travel.

(ii) Home-Characteristic Factor having the variables home value, rent, and lot size strongly associated with it in most of the groups; however, these variables were affected by the qualitative variables.

(iii) Car-Ownership Factor having the number of cars variables only associated with it in all groups except two where the family income variable was also associated with it. This factor was affected by the qualitative variables.

(iv) Family-Size Factor having the only variable number of children associated with it and was affected by the qualitative variables.

(v) and (vi) Status Factors having the variables education, occupation, income, family income, age and years at work strongly interrelated with them with different degrees of association depending on the qualitative variables.

2. The choice of non-collinear employee variables from the factors obtained should depend on other criteria than factor loadings or degree of association. These other criteria should include ease and economy of collecting data,consistency and stability of the variables, and the purpose of the study considered.

CHAPTER V

RELATIONSHIPS OF EMPLOYER AND EMPLOYEE CHARACTERISTICS

In this chapter, the employer and employee characteristics of the 20 work centers surveyed were analyzed to determine their interrelationships, and to generate a statistical model relating the number of work trip attractions to the significant employer and employee variables. This analysis was done in three steps. The first step was to analyze the association between the employer variables and to determine the variables that are strongly related to the number of work trip attractions variable. The second step was to analyze the association between the averages of the employee variables that were found in Chapter 4 as significant, and to determine the association between the two sets of significant employee and employer variables. The third step was to generate a multivariate statistical model relating the number of work trip attractions variable to the significant employer and employee variables, and to test this mathematical model obtained.

Analysis of Employer Variables

The analysis of the employer variables was done using factor analysis technique on the four quantitative employer variables collected: floor space, distance from the Atlanta central business district, assessed value of the work center, and the number of work trip attractions. Table 14 summarizes the data collected relating to these 20 work centers

Table 14. Work Centers Employers Data

Work Center	Floor Space	Distance From CBD	Assessed Value	Number of Attractions
A	224,450	1.0	5,611,400	1,037
B	194,932	0.0	1,960,000	744
C	110,000	0.0	4,400,000	650
D	466,410	0.0	3,731,280	1,100
E	280,000	0.0	2,445,970	1,000
F	196,483	21.0	5,648,310	1,300
G	873,707	1.5	3,430,900	1,350
H	214,800	15.0	1,362,830	2,203
I	715,000	1.0	6,242,150	4,500
J	126,000	5.0	990,500	917
K	207,241	12.0	1,243,446	500
L	395,682	0.0	3,594,420	1,207
M	52,000	4.0	208,000	200
N	94,500	0.0	756,000	200
O	401,316	1.8	269,530	800
P	361,405	3.0	905,950	1,400
Q	200,000	8.0	731,280	398
R	265,000	8.0	898,300	1,300
S	383,714	5.0	1,612,460	1,053
T	792,000	7.0	2,686,260	1,025

surveyed. The results of the varimax factor matrix of these employer variables is shown in Table 15. This table shows that the four employer variables were grouped into three independent factors. These three factors explained 90.0 percent of the total variance of the four employer variables. The first factor indicates that the number of work trip attractions variable is strongly associated with the floor space variable under one factor. The second factor is a single variable factor having the distance from the Atlanta central business district as the only variable that is strongly associated with this factor. This second factor implies that the number of work trip attractions variable is not related to the distance from the central business district variable. Conversely, the third factor indicates that the two variables: number of work trip attractions and the assessed value are interrelated and are strongly associated with the same factor.

Since the objective of this chapter is to generate a relationship relating the number of work trip attractions variables to the significantly related employer and employee variables, it is imperative to retain the two variables: floor space and assessed value, and to reject the distance from central business district variable from later consideration. This rejection of the distrance from central business district variable was done because of its weak association with the number of work trip attractions variable.

Analysis of Employer and Employee Variables

The analysis of the employer and employee variables was done by factor analyzing the two separate sets of significant variables related to the employer and to the employee. The significant employer variables

Table 15. Varimax Factor Matrix of Employer Variables (90. 0 percent)

Variable	FACTOR 1	2	3
Floor Space	(93.3)	-15.9	-12.2
Distance from CBD	-7.0	(98.8)	0.7
Assessed Value	15.9	-5.1	(-95.4)
Number of Attractions	(65.1)	15.7	(-57.3)
Eigenvalues	1.93	1.04	0.62

were chosen above and are: floor space, assessed value, and number of work trip attractions. The significant employee variables were determined by analyzing the averages of the independent pieces of information of Chapter 4. These employee variables chosen for factor analysis are: number of children, occupation, home value, number of cars, family income, and distance of travel.

The factor analysis of the averages of the above six employee variables of the 20 work centers surveyed resulted in the varimax factor matrix of Table 16. This table shows that the six employee variables were grouped into four independent factors which explained 93.0 per cent of the total variance of these variables. The first factor indicates that the average of the variables: occupation, home value, family income were very strongly interrelated under a single factor. The second factor is a single variable factor having the average number of children strongly associated with it. Similarly, the third factor is also a one-variable factor having the average distance of travel strongly related to it. Conversely, the fourth factor indicates that the averages of the two variables: number of cars and family income are highly interrelated under the same factor. These four factors show that these employee average variables could be represented by the four factors, in other words, by choosing one strongly associated variable from each factor. The chosen average variables are: number of children, occupation, number of cars, and distance of travel.

Having the two sets of significant variables of the employer and employee, a factor analysis was performed. The seven variables analyzed are: number of children, occupation, number of cars, distance of travel,

Table 16. Varimax Factor Matrix of Average Employee Variables (93.0 per cent)

Variable	FACTOR 1	2	3	4
Number of children	-8.1	(97.8)	-9.7	-5.5
Occupation	(92.0)	3.0	8.0	18.7
Home value	(82.7)	-35.3	15.5	16.3
Number of cars	26.5	-9.3	5.2	(94.8)
Family income	(75.8)	5.9	5.6	(58.5)
Distance of travel	12.8	-10.1	(98.4)	5.1
Eigenvalues	3.03	1.14	0.72	0.62

floor space, assessed value, and number of work trip attractions. The results of this analysis is summarized in the varimax factor matrix of Table 17. This table shows that the seven variables collapsed into five independent factors which explained 90.0 percent of the total variance of these variables. The first factor indicates that the variables: floor space, assessed value, and number of work trip attractions are strongly interrelated under this factor. The second factor shows that the variables: occupation and assessed value are strongly associated under a single independent factor and that the work trip attraction variable is not weakly associated with it. This table also shows that the third factor is a single variable factor with the number of children variable strongly associated with it. Conversely, the fourth factor indicates that the variable distance of travel is strongly associated with it, and the variable number of work trip attractions is relatively not weakly associated, too. The fifth factor is a single variable factor having the number of cars associated with it. Therefore, this varimax matrix shows that the number of work trip attractions variable appear to be associated with the factors one, two and four. So, by choosing one significant variable from each of these independent factors will determine the independent variables to be used in the component regression model relating the number of work trips to the employee and employer chararacteristics. The independent variables chosen to relate to the number of work trip attractions variable are: floor space, distance of travel, and occupation level.

Table 17. Varimax Factor Matrix of Employer and Average Employee Variables (90.0 per cent)

Variable	FACTOR 1	2	3	4	5
Number of children	2.1	4.1	(96.2)	-10.5	-5.5
Occupation	5.9	(-93.6)	-1.0	14.1	21.0
Number of cars	1.8	-23.3	-6.7	5.8	(96.0)
Distance of travel	7.2	-9.3	-10.8	(97.8)	5.5
Floor space	(78.1)	-3.8	36.4	-6.4	-16.4
Assessed value	(66.7)	(-58.5)	-12.2	-12.2	16.7
Number of attractions	(89.7)	(22.0)	-16.6	(33.3)	10.2
Eigenvalues	2.13	1.66	1.17	0.81	0.60

Work Trip Attractions Relationship

The work trip attraction relationship with the significant employee and employer variables is determined by using component analysis multivariate statistics. This component analysis starts by a principal component analysis on the independent variables: floor space, distance of travel, and occupation. This principal component analysis resulted in the grouping of these variables into components as shown in Table 18. This table indicates that the first component is strongly expressed by the variables occupation and distance of travel, while the second one is expressed by the floor space variable. Similarly, the third component is expressed by the variables occupation and distance of travel.

From the eigenvalues which represent the variance explained by their respective components, it is seen that the first component contains the largest amount of variance and that the third one contains the least amount of variance. The significance of the amount of variance explained by these eigenvalues is determined using Bartlett test of significance on each residual. Table 19 shows that when the third component is alone in the residual the test is not significant at 0.1 percent level. Conversely, the table shows the significance of the first two components at the same level of significance.

Having determined the significant components, the component analysis proceeds by using regression analysis on these orthogonal components. This component regression analysis generates the following multivariate statistical model:

Table 18. Components Matrix of Significant Employer and Average Employee Variables. (98.0 percent)

Variable	COMPONENT 1	2	3
Occupation	68.037	25.033	-68.878
Distance of travel	70.118	5.101	71.117
Floor space	-21.316	96.682	14.081
Eigenvalues	1.21899	0.99387	0.78712

$$y = -240.37x_1 + 163.12x_2 + 2.10x_3 - 515.48$$

where:

x_1 = average occupation level

x_2 = average distance of travel between home and place of work

x_3 = floor space, and

y = number of trips attracted to the work centers.

The above model can be expressed in its standardized coefficients form as:

$$y = -0.142x_1 + 0.338x_2 + 0.530x_3$$

where the terms are defined as before. These standardized coefficients correspond to the variables expressed with zero means and unit variances. These coefficients show that the variable floor space contributes the most to the model and the variable occupation level contributes the least to the model.

The F-ratio test of significance of the component regression model was performed and the results tabulated in Table 20 indicate that the model is significant at the 0.001 percent level. Conversely, the coefficient of multiple determination of the above component regression model is 0.378 which implies only about 38 percent of the variation in the number of trip attractions to the work centers is explained by the model. Also, the efficiency of the model is about 14 percent, which is relatively low for predictive uses. However, it is worth noting that the structure of this model expresses a rational relationship between the variables involved. The model confirms the previous findings on the strong relation between the number of work trip attractions and

Table 19. Bartlett Test of Significance

Residual	Degrees of Freedom	Chi-square	Chi-square (0.10)
2, 3	3	8.15	6.25
3	1	2.25	2.70

Table 20. F-Test of Significance of the Component Regression Model.

Source	Sum of Squares	Degrees of Freedom	F-Ratio	F(0.001)
Regression	42,112,690	3	22.65	9.00
Error	9,905,551	16		
Total		19		

the floor space variables (20), (21), (22). The model also shows that the variables average occupation level and average distance of travel affect the number of work trip attractions to the work centers. The model implies that the work centers that have the greater number of work trip attractions are the ones that employ a larger number of blue-collar workers. Conversely, it suggests that the larger work centers tend to attract workers from a greater distance from the center in order to satisfy their larger demand of skills.

Summary of Relationships of Employer and Employee Characteristics

In this summary of analysis of relationships between the employer and employee variables of the 20 large work centers surveyed in the Atlanta Metropolitan Area, the following points can be stated.

1. The four employer variables collapsed into three factors that explained 90 percent of the total variance of these variables. The variables floor space and number of work trip attractions were strongly associated under one factor. The variable distance from central business district appeared under a single variable factor independent from the others. The variables assessed value and number of work trip attractions were strongly associated under a single factor.

2. The factor analysis of the employer and average employee variables resulted in only three factors significantly associated with the number of work trip attractions variable. The variables that were chosen from these factors to relate to the work trip attractions variable are: floor space,

occupation level, and average distance of travel.

3. The component regression model relating the number of work trips to the above chosen variables had a coefficient of determination of only 38 percent.

CHAPTER VI

CONCLUSIONS

The following conclusions can be made from this investigation:

1. Factor analysis multivariate statistical techniques can be used to determine the interrelationships and degree of association between the socio-economic and travel variables related to the employee and place of work.

2. The 13 employee quantitative variables collapsed into six independent factors that explained more than 82 percent of the total variance of these variables. These six factors are:

(i) Travel Factor having the variables time and distance of travel strongly associated with it.

(ii) Home-Characteristic Factor having the variables home value, rent, and lot size strongly associated with it.

(iii) Car-Ownership Factor having number of cars variable only associated with it.

(iv) Family-Size Factor having the only variable number of children associated with it.

(v) and (vi) Status Factors having the variables education, occupation, income, family income, age, and years at work strongly interrelated with them.

3. The above factors with the exception of the Travel Factor were affected by the qualitative variables: sex, marital status, and mode of travel.

4. The four employer related variables collapsed into three independent factors that explained 90 percent of the total variance of these variables.

5. The employer related variables floor space and number of work trip attractions to the work centers were strongly associated under one independent factor.

6. The employer related variable distance of work center from the Atlanta central business district appeared as an independent factor and was not associated with the other employer related variables.

7. The employer related variables assessed value and number of work trip attractions to the work centers were strongly interrelated under a single factor.

8. Component analysis multivariate statistical technique was used to determine a multivariate statistical model relating the number of work trip attractions variable to the significant employer and employee variables. The component regression model generated shows that the number of work trips attracted to the work centers depends on the floor space of the center, and on the average occupation level and average distance of travel of the employees of this center. It is worth noting that the coefficient of multiple determination of the model was not high.

9. It is noted that the above results are based on work centers that have large number of employees, and that they might not be true for smaller work centers.

CHAPTER VII

RECOMMENDATIONS

The following implications and recommendations can be made from the results and problems encountered in this research study:

1. Knowing the interrelationships between the socio-economic and travel variables related to the employee and employer, planners should be able to choose non-redundant variables in conducting their planning studies. The use of only these non-redundant will result in an efficient questionnaire having only about half of the questions asked in Table 2. This will result in a tremendous reduction in cost of data collection and analysis and in a better response of the persons surveyed.

2. The choice of the non-redundant variables should depend on the degree of association between the variables, the ease and economy of collecting data, the consistency and stability of the variables, and the purpose of the study considered.

3. The generation of a trip attraction model by large work centers instead of by zones could be used in small area planning studies such as central business district planning studies. However, it is recommended that future research be done to increase the coefficient of determination of the mathematical model obtained. One possibility of improvement of the model is to group the work centers according to the type of work activity and to generate one model for each type of activity.

4. Similar studies should be undertaken in other urban areas than Atlanta to determine the effect of the size of the urban area and to generalize the relationships between the employee and employer connected variables.

5. A possibility of future study would be to further analyze the effects of the qualitative employee variables by using multiple discriminate multivariate analysis to distinguish differences and to determine those variables which contribute most significantly to the group separation.

6. The results of the interrelationship between the employee and employer connected variables could be analyzed by social scientists and psychologists to determine the causes of these interrelationships.

7. The variable occupation rating appeared as a reliable measure of the employee status when measured on an individual basis. Averages of these ratings appeared to reliably describe the occupational characteristics of the work centers. The importance of this variable suggests a need for studying the effects of the backgrounds of the panel of judges who performed the ratings.

8. Future studies should be undertaken to extend the results of this investigation to work centers that have moderate and small numbers of employees.

APPENDIX 1

QUESTIONNAIRE

Postage Will be Paid by Addressee

BUSINESS REPLY MAIL
First Class Permit No. 5748 Atlanta, Ga.

No Postage Stamp Necessary If Mailed in the United States

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF CIVIL ENGINEERING
(PROJECT B – 615)
ATLANTA, GEORGIA 30332

14784

This Study is Being Conducted in Cooperation with

The State Highway Department of Georgia

The City of Atlanta Planning Department

The Atlanta Region Metropolitan Planning Commission

A research study is being conducted at Georgia Tech of work travel in the Atlanta area. From this study it is hoped that a better understanding will be developed of work trips and the congestion which typically occurs during peak hours of travel.

Your COOPERATION and ASSISTANCE is needed to insure the success of this study. Would you please complete this questionnaire and mail it at your earliest convenience.

The information you provide will be kept in CONFIDENCE, in the sense that individual addresses will not be shown in the research project. YOU DO NOT HAVE TO SIGN THIS QUESTIONNAIRE.

Thank you very much for your help.

EMPLOYEE SURVEY

County where you live ______________________________

City where you live ______________________________

Nearest street intersection to your home: ____________________ and ____________________

Age: _____ Race: _____ White Sex: _____ Male

_____ Nonwhite _____ Female

Marital Status: _____ Single _____ Married _____ Widowed

_____ Divorced/Separated

Number of children: _____

What is your occupation or profession: ______________________________

Check the educational group or/and groups <u>you</u> belong to:

_____ 8 grades of school or less _____ Secretarial, business

_____ Completed high school _____ Have college degree

_____ Some college

Number of years employed in this place of work: _____ years

Do you drive your car to work _____; ride the bus _____; walk _____; car pool _____; other _____.

Do you own your home: yes _____; What is its value $__________.

no _____; How much rent do you pay per month $__________.

If you own your house what is its lot size?

_____ Less than 1/8 acre _____ Between 1/8 acre to 1/2 acre _____ Larger than 1/2 acre.

Estimate of your distance from home to work: _____ miles.

How many minutes does it take you to get from home to work: _____ minutes.

Check the personal income group <u>you</u> belong to:

_____ under $2,000 _____ $4,000 - $4,999 _____ $7,500 - $9,999

_____ $2,000 - $2,999 _____ $5,000 - $5,999 _____ $10,000 - $14,999

_____ $3,000 - $3,999 _____ $6,000 - $7,499 _____ $15,000 - Or more

Are you the head of the house? _____ yes _____ no

Check your <u>total family</u> income group:

_____ under $2,000 _____ $4,000 - $4,999 _____ $7,500 - $9,999

_____ $2,000 - $2,999 _____ $5,000 - $5,999 _____ $10,000 - $14,999

_____ $3,000 - $3,999 _____ $6,000 - $7,499 _____ $15,000 - Or more

Number of cars in the family: _____

How many blocks do you walk from parking lot, bus stop or street corner to your place of work? _____

If you car pool, how many persons ride with you? _____

APPENDIX 2

OCCUPATION RATING

Table 21. Description of Occupation Raters

Judge	Race	Sex	Marital Status	Profession/Occupation
1	White	Female	Married	Home Economist
2	Non-white	Male	Married	Planner
3	White	Male	Married	Social Scientist
4	White	Female	Single	Psychologist
5	White	Male	Married	Psychologist
6	White	Male	Single	Civil Engineer
7	White	Male	Married	City Planner
8	White	Female	Married	School Teacher
9	White	Male	Married	Civil Engineer
10	White	Female	Widowed	Secretary

OCCUPATION RATING

How would you judge the following occupations? For example, which statement below gives your personal opinion of the general standing of a telephone operator. Which number from the list below would you pick out for him?

5 - <u>Excellent</u> standing

4 - <u>Good</u> standing

3 - <u>Average</u> standing

2 - <u>Somewhat below average</u> standing

1 - <u>Poor</u> standing

On the line to the left of each occupation listed below, please write the number which indicates <u>your</u> rating of the job.

Table 22. North-Hatt Occupational Scale Technique

Occupation	Rates Assigned By Judge						Sum of Rates $V\alpha$
	1	2	. . .	β	. . .	10	
1	$V_{1,1}$	$V_{1,2}$	. . .	$V_{1,\beta}$	. . .	$V_{1,10}$	V_1
2	$V_{2,1}$	$V_{2,2}$	. . .	$V_{2,\beta}$	. . .	$V_{2,10}$	V_2
.	.	.	.	.	.	.	.
.	.	.	. . .	.	. . .	.	.
.	.	.	.	.	.	.	.
α	$V_{\alpha,1}$	$V_{\alpha,2}$	.	$V_{\alpha,\beta}$	.	$V_{\alpha,10}$	V_α
.	.	.	.	.	.	.	.
.	.	.	. . .	.	. . .	.	.
.	.	.	.	.	.	.	.
271	$V_{271,1}$	$V_{271,2}$	. . .	$V_{271,\beta}$	. . .	$V_{271,10}$	V_{271}

$$V_\alpha = \sum_{\beta=1}^{10} V_{\alpha,\beta} \qquad \alpha = 1, 2, ---, 271$$

and

UTILITY RATE:

$$U_\alpha = \frac{V_\alpha}{\sum_{\alpha=1}^{271} V_\alpha} \qquad \alpha = 1,2,---, 271$$

Table 23. Occupation Utility Rates

Utility Rate	Occupation	Utility Rate	Occupation
0.0049335	Civil Engineer	0.0034419	Building Inspector
0.0030978	Accounting Clerk	0.0033272	Deputy Marshal
0.0030978	Highway Technician	0.0051629	Dir. of Public Works
0.0043598	Highway Planner	0.0024094	Maintenance Mechanic
0.0041303	Office Manager	0.0032125	Fire Inspector
0.0037861	Land Surveyor	0.0017210	Gardener
0.0044745	Landscape Architect	0.0043598	Administrator
0.0041303	Office Supervisor	0.0032125	Plumbing Inspector
0.0041303	Auditor	0.0033272	Housing Inspector
0.0026388	Storekeeper	0.0044745	Budget Analyst
0.0019504	Duplicating Machine Operator	0.0040156	Social Worker
0.0024094	Key Punch Operator	0.0036714	Legal Secretary
0.0032125	Secretary	0.0037861	Probation Officer
0.0041303	Statistical Analyst	0.0036714	Deputy Sheriff
0.0026388	Teleprint Operator	0.0040156	Public Relations
0.0051629	Attorney	0.0053924	Judge
0.0030978	Draftsman	0.0026388	Carpenter
0.0048187	Personnel Director	0.0037861	Registrar
0.0040156	Computer Programmer	0.0048187	Comptroller
0.0048187	Director of Statistics	0.0026388	Stationary Fireman
0.0037861	Right of Way Appraiser	0.0047040	Department Head
0.0025241	Coding Clerk	0.0036714	Crime Investigator
0.0037861	Commercial Artist	0.0050482	County Commissioner
0.0037861	Dir., Truck Weighing Div.	0.0034419	Case Worker
0.0041303	Finance Officer	0.0032125	Court Clerk
0.0016062	Laborer	0.0029830	Tax Clerk
0.0025241	Typist	0.0034419	Welfare Worker
0.0030978	Stenographer	0.0030978	Law Clerk
0.0034419	Computer Operator	0.0048187	Assistant Dist. Attn.
0.0028683	Bookkeeper	0.0033272	Engineering Assistant
0.0040156	Accountant	0.0037861	Supervisor
0.0035567	Construction Inspector	0.0029830	Printer
0.0032125	Inspector	0.0034419	Tax Collector
0.0043598	Systems Analyst	0.0045893	Prosecutor
0.0022946	Painter	0.0051629	Electrical Engineer
0.0024094	Traffic Checker	0.0039009	Specification Writer
0.0044745	Public Administrator	0.0041303	Equipment Engineer
0.0030978	Policeman	0.0041303	Program Planner
0.0042451	General Manager	0.0043598	Personnel Supervisor
0.0025241	Cashier	0.0044745	Department Chief
0.0030978	Planning Technician	0.0043598	Electronics Instructor
0.0048187	City Planner	0.0044745	System Designer
0.0035567	Printing Supervisor	0.0036714	Cost Estimator
0.0028683	Electrician	0.0035567	Cable Engineer
0.0033272	Revenue Collector	0.0045893	Engineering Supervisor

(Continued)

Table 23. continued

Utility Rate	Occupation	Utility Rate	Occupation
0.0028683	Schedule Clerk	0.0037861	Quality Assurance
0.0044745	Industrial Engineer	0.0028683	Engineering Aid
0.0030978	Custodian Supervisor	0.0047040	Consulting Engineer
0.0032125	Athletic Director	0.0035567	Quality Control
0.0041303	Assistant Manager	0.0034419	Claim Adjustor
0.0027536	Teller	0.0035567	Librarian
0.0028683	Purchasing Clerk	0.0025241	Serviceman
0.0050482	Physician	0.0043598	Management Developer
0.0039009	Superintendent, Buildings and Grounds	0.0033272	Welfare Case Worker
		0.0032125	Freight Accountant
0.0014915	Janitor	0.0039009	Nurse
0.0042451	Executive Secretary	0.0035567	Communications Asst.
0.0036714	Secretary-Translator	0.0045893	Marketing Manager
0.0042451	Package Engineer	0.0035567	Credit Representative
0.0044745	Training Director	0.0041303	Designer
0.0037861	Purchasing Agent	0.0027536	Freight Payment Clerk
0.0033272	Sales Correspondent	0.0032125	Design Art Assistant
0.0035567	Traffic Manager	0.0041303	Information Services Manager
0.0040156	Industrial Relations		
0.0043598	Economist	0.0034419	Industrial Photographer
0.0044745	Mechanical Engineer	0.0039009	Inventory Control Anal.
0.0043598	New Products Proj. Leader	0.0024094	Sewing Machine Oper.
0.0028683	Payroll Clerk	0.0036714	Quality Control
0.0028683	Examiner	0.0021799	Truck Driver
0.0025241	Sewing Machine Mechanic	0.0021799	Binder
0.0022946	Seamstress	0.0021799	Clothing Worker
0.0041303	Warehouse Manager	0.0045893	Plant Engineer
0.0036714	Receiving Supervisor	0.0022946	Packer
0.0027536	Insurance Clerk	0.0025241	Shipper
0.0044745	Personnel Manager	0.0037861	Production Expeditor
0.0022946	Stock Clerk	0.0027536	Timekeeper
0.0028683	Order Selector	0.0025241	Weight Checker
0.0037861	Purchasing Agent	0.0045893	Advertising Director
0.0028683	Baker	0.0024034	Food Handler
0.0024094	Mixer	0.0033272	Foreman
0.0026388	Machine Operator	0.0028683	Technician
0.0017210	Floor Sander	0.0034419	Production Scheduler
0.0040156	Packing Superintendent	0.0022946	Lift Operator
0.0035567	Sanitation Specialist	0.0014915	Porter
0.0035567	Cafeteria Supervisor	0.0047040	Professional Educator
0.0040156	Civil Defense Admn.	0.0036714	Revenue Collection
0.0043598	Zoning Administrator	0.0035567	Traffic Investigator
0.0049335	School Administrator	0.0044745	Teacher
0.0044745	Counselor	0.0034419	Field Representative
0.0043598	Chief Registrar	0.0049335	Director of Department

(Continued)

Table 23. continued

Utility Rate	Occupation	Utility Rate	Occupation
0.0039009	Tax Assessor	0.0042451	System Coordinator
0.0040156	Assistant Director	0.0036714	Artist
0.0025241	Merchandise Handler	0.0032125	Merchandise Inspector
0.0033272	Retail Requisitioner	0.0026388	Security Officer
0.0035567	Credit Authorizer	0.0040156	Customer Relations
0.0029830	Comptometer Operator	0.0019504	Cook
0.0022946	Billing Clerk	0.0040156	Buyer
0.0032125	Technical Instructor	0.0042451	Field Service Manager
0.0044745	Dir. of Civic Affairs	0.0035567	Appraiser
0.0020652	Stockman	0.0032125	Staff Assistant
0.0049335	Manager	0.0036714	Group Leader
0.0036714	Pilot	0.0034419	Service Representative
0.0034419	Inventory Control	0.0043598	Retail Store Planner
0.0013768	Main	0.0030978	Credit Interviewer
0.0041303	Psychometrist	0.0039009	Industrial Publication Editor
0.0034419	Group Leader		
0.0022946	Fork Lift Driver	0.0019504	Floor Finisher
0.0030978	Expeditor	0.0030978	Adjustor
0.0022946	Student Trainee	0.0037861	Liaison Merchandiser
0.0017210	Messenger	0.0027536	Lead Lady
0.0041303	Training Coordinator	0.0048187	Market Analyst
0.0040156	Petroleum Pricing	0.0037861	Medical Secretary
0.0040156	Sales Promotion	0.0027536	Tab Operator
0.0035567	Magazine Writer	0.0047040	General Directory Mgr.
0.0048187	Gen. Personnel Supervisor	0.0045893	Plant Supervisor
0.0035567	Illustrator	0.0042451	Economic Research
0.0033272	Photography	0.0041303	Project Engineer
0.0037861	Steam Heat Engineer	0.0051629	District Manager
0.0039009	Building Superintendent	0.0019504	Meter Reader
0.0025241	Saleslady	0.0026388	Receptionist
0.0034419	Pension Analyst	0.0034419	Land Surveyor
0.0032125	Recreation Representative	0.0022946	Apprentice Mechanic
0.0030978	Forester	0.0022946	Student Co-op
0.0028683	Trouble Dispatcher	0.0041303	Home Economist
0.0024094	Telephone Operator	0.0021799	Rodman
0.0034419	Document Writer	0.0037861	Journalist
0.0025241	PBX Operator	0.0045893	Promotion Manager
0.0025241	Projectionist	0.0044745	Advertising Specialist
0.0039009	Compensation Serv. Coordinator	0.0049335	Chemist
0.0025241	Power Machine Operator	0.0030978	Lab Technician
0.0037861	Actuary	0.0032125	Salesman
0.0049335	Chemical Engineer	0.0036714	Government Affairs
0.0050482	Psychologist	0.0018357	Guard
0.0044745	Financial Analyst	0.0056218	Vice Pres. Marketing
0.0047040	Computer Operations Department Manager	0.0055071	Vice President
		0.0044745	Industrialist

(Continued)

Table 23. continued

Utility Rate	Occupation	Utility Rate	Occupation
0.0036714	Building Supervisor	0.0042451	Trade Researcher
0.0042451	Industrial Designer		

APPENDIX 3

EIGENVALUE, EIGENVECTOR

APPENDIX 3

EIGENVALUE, EIGENVECTOR

Definition (74), (75), (76)

Consider a system of linear homogeneous equations ($\underline{A}$ - E $\underline{I}$) $\underline{X}$, where $\underline{A}$ is an nxn matrix, $\underline{X}$ is a vector of order n, and $\underline{I}$ is an identity matrix. This homogeneous set of equations possess only the trivial solution $\underline{X} = \underline{0}$, unless the determinant of coefficients, denoted by det ($\underline{A}$ - E $\underline{I}$), is zero. That is:

$$\det (\underline{A} - E\ \underline{I}) = 0.$$

The equation det ($\underline{A}$ - E $\underline{I}$) = 0 is a polynomial in E of degree n, known as the characteristic equation of the matrix $\underline{A}$. The roots of this equation are special values of E for which the linear homogeneous equations posses non-zero solutions. These roots are called Eigenvalues of $\underline{A}$.

Corresponding to each of these eigenvalues there will be a solution of the homogeneous equations of the form $\underline{C} = 1\underline{X}$ where $\underline{X} \neq \underline{0}$, and 1 is an arbitrary constant. These solutions are called the Eigenvectors of $\underline{A}$.

Numerical Solution of the Characteristic Equation (77),(78), (79)

There exist several computer oriented numerical techniques to solve the characteristic equation of the matrix $\underline{A}$. In this investigation, the iterative method developed by Hotelling was chosen. This method has the advantage that the elements of the eigenvectors corresponding to any root of the characteristic equation are found simultaneously. It also has the property of generating the eigenvalues in descending order of magnitudes. The steps involved in this numerical technique are:

(a) Compute the sum of each column of matrix $\underline{A}$.

(b) Standardize the values of the sum row by making the largest sum equal to unity. This will be the column vector: iteration 1.

(c) Multiply each column of matrix $\underline{A}$ by the vector iteration 1 and sum to obtain the first product values.

(d) Standardize the values of the first product values as in step (a), to obtain the iteration vector 2.

(e) Repeat this process until there is no change in the iteration vector calculation. The vector obtained will be the first eigenvectors.

(f) Normalize the above vector by making the resultant of its elements equal to unity to obtain the new eigenvector.

(g) To obtain the corresponding eigenvalue, multiply the eigenvector of step (f) by the first column of the matrix $\underline{A}$ and sum.

(h) To get the next eigenvector, form a symmetrical matrix from the eigenvector obtained in (f) by taking the squares and cross-products of its elements.

(i) Multiply the matrix formed in step (h) by the eigenvalue E_1.

(j) Form the "deflated matrix" by subtracting the matrix obtained in step (i) from the matrix $\underline{A}$ to get the new matrix $\underline{A}_1$.

(k) Repeat the previous steps of the iterative method on matrix $\underline{A}_1$ to obtain all eigenvalues and eigenvectors.

An illustration of the above algorithm of the Hotelling method of determining the eigenvalue and eigenvectors of matrix A is shown in the following example:

$$\underline{A} = \begin{bmatrix} 1.0 & 0.13 & 0.18 \\ 0.13 & 1.0 & 0.95 \\ 0.18 & 0.95 & 1.0 \end{bmatrix}$$

(a) Sum 1.31 2.08 2.13

(b) Iteration 1 $\begin{bmatrix} 0.6150 \\ 0.9765 \\ 1.0000 \end{bmatrix}$

(c) First product 0.9219 2.0064 2.0384

(d) Iteration 2 0.4523 0.9843 1.0000

(e) First Eigenvector

$$\begin{bmatrix} 0.3097 \\ 0.9920 \\ 1.0000 \end{bmatrix}$$

(f) Normalized Eigenvector

$$\begin{bmatrix} 0.2147 \\ 0.6878 \\ 0.6933 \end{bmatrix}$$

(g) $E_1 = 1.9977$

(h) $\begin{bmatrix} 0.04610 & 0.14767 & 0.14885 \\ 0.14767 & 0.47307 & 0.4769 \\ 0.14885 & 0.4769 & 0.48066 \end{bmatrix}$

(i) $\begin{bmatrix} 0.0921 & 0.2950 & 0.2974 \\ 0.2950 & 0.9451 & 0.9527 \\ 0.2974 & 0.9427 & 0.9602 \end{bmatrix}$

(j)
$$A_1 = \begin{bmatrix} 0.9079 & -0.1650 & -0.1174 \\ -0.1500 & 0.0549 & -0.0027 \\ -0.1174 & -0.0027 & 0.0398 \end{bmatrix}$$

Properties of the Eigenvalues and Eigenvectors

The following are some significant properties of eigenvalues and eigenvectors:

1. The sum of the eigenvalues is equal to the dimension of the matrix $\underline{A}$ if the elements of $\underline{A}$ are normalized.
2. The eigenvectors of the matrix $\underline{A}$ are ortho-normal, i.e., they are orthogonal since the cross product of any two eigenvector is equal to unity.

APPENDIX 4

VARIMAX METHOD OF ROTATION

APPENDIX 4

VARIMAX METHOD OF ROTATION

Definition (80), (81)

Considering the factor pattern resulting from the principal component solution, it is desirable to simplify the column factors of the factor matrix so that the solution will satisfy Thrustone's principle of "simple structure":

1. Each row of the factor matrix should have at least one zero.
2. If there are m common factors, each column of the factor matrix should have at least m zeros.
3. For every pair of columns of the factor matrix there should be several variables whose entries vanish in one column but not in the other.
4. For every pair of columns of the factor matrix, a large proportion of the variables should have vanishing entries in both columns when there are four or more factors.
5. For every pair of columns of the factor matrix there should be only a small number of variables with non-vanishing entries in both columns.

In order to achieve the above principle of "simple structure", Kaiser developed an analytical method called varimax.

Varimax Method (82), (83), (84)

The varimax method of rotation starts by computing the simplicity, v_k, of every factor k, of the factor matrix. The simplicity of a factor k is defined as the variance of its squared factor loadings, i.e.:

$$v_k^{\ 2} = \frac{1}{p} \sum_{i=1}^{p} (b_{ik}^2)^2 - \frac{1}{p^2} \left(\sum_{i=1}^{p} b_{ik}^2 \right)^2$$

where:

$b_{ik} = i^{th}$ factor loading of factor k of the factor matrix, and,

p = number of variables observed, x,

The second step is to maximize the function, V, representing the simplicities of all factors of the factor matrix:

$$V = p \sum_{k=1}^{m} \sum_{i=1}^{p} \left(\frac{b_{ik}}{h_i} \right)^4 - \sum_{k=1}^{m} \left[\sum_{i=1}^{p} \left(\frac{b_{ik}}{h_i} \right)^2 \right]^2$$

where:

m= number of common factors,

h_i^2 = common factor variance of the i^{th} observed variable X_i, and

b_{ik}, p as defined before.

The solution of the above function, V, is equivalent to finding a transformation matrix, $\underline{T}$, that rotates the matrix $\underline{A}$, of normalized factor loadings such that:

$$\underline{B} = \underline{A} \cdot \underline{T},$$

where matrix, $\underline{B}$, maximizes the function V.

The above transformation of factors is done by rotating two factors at a time, and the complete cycle of $\frac{m}{2}$ (m - 1) pairings of factors is repeated until the value of the function, V no longer increases.

To illustrate the steps involved in one iteration of the above transformation, consider the factor loadings of a variable X_i for a particular pair of factors F_1 and F_2 be designated respectively by b_iF_1 and b_iF_2:

(a) Normalize the factor loadings of F_1 and F_2 by dividing the factor loadings by the common factor variance, h_i, of the variable X_i to obtain:

$$y_i = \frac{b_iF_1}{h_i} \quad \text{and} \quad z_i = \frac{b_iF_2}{h_i}$$

(b) Form the vector of the normalized factor loadings to get:

$$(y_i \; z_i)$$

(c) Calculate the difference of the squared factor loadings and their product from the following:

$$d_i = y_i^2 - z_i^2$$

$$w_i = 2_{yi}z_i$$

(d) Compute the angle of rotation from the relation:

$$\tan 4\phi = \frac{2\sum_{i=1}^{p} d_i - \frac{2}{p}\sum_{i=1}^{p} d_i \sum_{i=1}^{p} w_i}{\sum_{i=1}^{p}(d_i^2 - w_i^2) - \frac{1}{p}\left[\left(\sum_{i=1}^{p} d_i\right)^2 - \left(\sum_{i=1}^{p} w_i\right)^2\right]}$$

(e) Having the angle of rotation, form the transformation matrix of rotation, $\underline{T}$:

$$\underline{T} = \begin{bmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{bmatrix}$$

(f) To obtain the rotated normalized factor loadings (Y_iZ_i) for this iteration, the original normalized factor loadings vector (y_iz_i) is multiplied by the transformation matrix $\underline{T}$ as follows:

$$(Y_i Z_i) = (y_i z_i) \begin{bmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{bmatrix} .$$

It is worth mentioning the advantage of using the varimax method for simple structure over other methods of rotation. This advantage is that the solution obtained by varimax is invariant under changes in the set of variables. Thus, this invariance property permits inferences to be drawn from the factors derived from a sample to the universe varimax factors.

APPENDIX 5

VARIMAX FACTOR MATRICES

Table 24 . Varimax Factor Matrix Male Single Drive to Work Group of Work Center H. (88.5 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	(68.7)	(44.5)	11.1	-18.3	10.7	-12.4
Occupation	(89.0)	5.4	-2.7	24.8	-3.9	7.8
Education	28.0	0.5	-3.2	(85.9)	9.8	6.0
Years at work	(51.0)	35.3	2.1	(-47.3)	32.6	16.1
Home value	16.4	(94.6)	1.5	-2.8	17.5	-8.3
Rent	16.1	-13.5	-3.2	3.0	-4.9	(96.6)
Lot size	7.1	(95.6)	16.9	-0.3	3.1	-7.3
Cars	0.2	15.6	-7.9	5.8	(95.7)	-5.5
Income	(95.6)	5.3	-11.6	10.0	0.7	11.9
Family income	(95.6)	5.3	-11.6	10.0	0.7	11.9
Time of travel	-0.1	9.3	(94.7)	7.9	-3.5	3.7
Distance of travel	-13.9	8.6	(92.6)	-13.2	-5.0	-8.2
Eigenvalues	4.00	2.49	1.58	1.00	0.84	0.72

Table 25. Varimax Factor Matrix Male Single Drive to Work Group of Work Center G. (90.8 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	10.3	(-95.7)	-6.8	11.8	3.3	0.4
Occupation	-1.7	26.5	21.0	38.8	(75.3)	-6.4
Education	9.5	(55.7)	23.1	(43.6)	(44.2)	14.1
Years at work	0.7	(-97.0)	-6.6	-3.5	-7.1	-9.6
Home value	(97.5)	-3.8	-4.6	11.9	-5.4	-15.6
Rent	(-41.7)	14.1	12.2	8.8	14.5	(85.4)
Lot size	(97.5)	-3.3	-5.0	12.3	-6.0	-15.1
Cars	14.5	9.2	4.5	26.4	(-87.7)	-19.1
Income	17.9	-11.6	-5.4	(88.1)	28.2	18.2
Family income	8.6	4.5	12.3	(93.2)	-26.3	-8.4
Time of travel	-3.0	0.9	(92.1)	-3.8	-2.6	1.2
Distance of travel	-6.1	6.2	(90.5)	9.0	8.2	8.0
Eigenvalues	2.99	2.66	1.79	1.71	1.25	0.50

Table 26. Varimax Factor Matrix Male Single Drive to Work Group of Work Center B. (89.5 per cent)

Variable	FACTOR 1	2	3	4	5
Age	(87.1)	-1.7	-35.0	-8.3	-3.0
Occupation	35.7	-3.1	(-76.8)	3.5	(43.2)
Education	1.0	0.6	(-90.7)	-30.7	-2.7
Years at work	(92.9)	1.0	3.1	-5.0	23.0
Rent	21.7	-25.5	-20.6	-34.2	(82.1)
Cars	-17.2	(89.1)	26.3	19.0	-12.6
Income	61.6	5.9	(-68.5)	-8.3	25.2
Family income	19.9	(88.4)	-30.1	15.9	10.5
Time of travel	-6.6	13.3	6.3	(88.9)	-4.8
Distance of travel	-5.4	17.4	19.4	(81.9)	-23.3
Eigenvalues	4.12	2.22	1.19	0.88	0.54

Table 27. Varimax Factor Matrix Male Single Drive to Work Group of Work Center L. (88.2 per cent)

Variable	FACTOR 1	2	3	4	5
Age	(83.8)	2.7	(47.2)	0.9	-5.5
Occupation	16.5	-10.9	(88.0)	-2.7	10.7
Education	7.4	-3.7	(92.9)	4.0	6.9
Years at work	(80.2)	9.0	-15.0	-3.8	24.8
Home value	(90.5)	-2.5	24.2	-5.8	-23.4
Rent	-19.1	-15.3	29.1	15.0	(82.9)
Lot size	(90.5)	-2.5	24.2	-5.8	-23.4
Cars	-7.3	20.9	-22.6	(-79.4)	(-42.3)
Income	(41.9)	11.3	(78.8)	-17.6	27.0
Family income	15.0	15.1	23.5	(-91.1)	6.7
Time of travel	2.2	(94.6)	1.6	-14.5	-6.0
Distance of travel	2.3	(94.1)	-8.1	-12.8	-8.7
Eigenvalues	4.32	2.72	1.76	1.12	0.67

Table 28 . Varimax Factor Matrix Female Single Drive to Work Group of Work Center H. (91.4 per cent)

Variable	FACTOR 1	2	3	4	5
Age	36.7	-6.1	0.4	0.6	(-87.8)
Occupation	(95.6)	2.3	12.2	5.5	-5.0
Education	25.9	7.5	(-89.8)	11.9	3.8
Years at work	7.7	-13.6	(55.4)	34.1	(-60.1)
Rent	2.3	-31.0	-6.3	(92.2)	-7.8
Income	(89.9)	-5.1	-29.9	0.0	-25.8
Family income	(89.9)	-5.1	-29.9	0.0	-25.8
Time of travel	-0.1	(94.5)	-11.4	-14.9	-8.1
Distance of travel	-0.4	(91.4)	-0.4	-20.3	23.2
Eigenvalues	3.34	2.34	1.32	0.72	0.51

Table 29. Varimax Factor Matrix Female Single Drive to Work Group of Work Center G. (90.5 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	(88.2)	23.1	-2.0	-2.9	26.7	3.8
Occupation	10.7	-1.8	-0.4	-21.8	(93.2)	16.9
Education	7.2	-10.2	-5.7	-23.3	24.6	(89.9)
Years at work	(92.4)	22.3	5.8	-11.2	12.5	3.0
Home value	30.5	(91.6)	6.9	4.0	4.9	1.2
Rent	3.3	(-47.0)	(-66.6)	-7.6	10.4	35.0
Lot size	16.3	(94.4)	-0.2	12.9	3.7	-11.2
Cars	-15.9	-13.2	(91.0)	3.3	-21.5	-3.4
Income	(49.2)	12.3	-5.0	-7.2	(81.1)	15.6
Family income	23.4	8.3	(89.4)	3.6	24.5	9.1
Time of travel	10.2	3.0	-4.2	(86.5)	-11.0	-32.1
Distance of travel	-27.9	15.9	15.3	(84.4)	-16.7	2.3
Eigenvalues	3.64	2.96	1.82	1.00	0.84	0.60

Table 30. Varimax Factor Matrix Female Single Drive to Work Group of Work Center I. (89.5 per cent)

Variable	FACTOR 1	2	3	4	5
Age	(86.2)	-15.4	29.6	-6.6	1.5
Occupation	17.1	-8.0	(87.7)	3.8	26.1
Education	-4.2	-5.0	28.6	-8.6	(94.8)
Years at work	(89.9)	-3.9	29.9	-4.6	1.9
Home value	(92.0)	4.1	13.1	-0.6	-3.5
Rent	(-46.9)	(-65.1)	34.4	-31.7	-5.3
Lot size	(96.6)	-3.5	0.0	5.2	-3.1
Cars	-34.6	(82.9)	-12.0	25.4	-2.0
Income	37.4	(5.5)	(84.4)	1.6	9.8
Family Income	-0.4	(94.5)	14.3	-1.8	-3.0
Time of travel	-5.3	9.3	11.8	(94.8)	5.0
Distance of travel	2.3	14.6	7.9	(94.6)	-14.9
Eigenvalues	4.28	2.72	1.77	1.37	0.60

Table 31. Varimax Factor Matrix Female Single Drive to Work Group of Work Center D. (89.6 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	24.0	4.8	-2.2	(-91.4)	7.5	-3.8
Occupation	3.1	18.6	5.3	19.1	(88.5)	9.6
Education	7.6	36.1	6.1	(77.2)	38.0	-7.0
Years at work	(40.1)	0.7	-11.7	(-77.9)	7.0	-17.9
Home value	(92.1)	-10.9	19.5	-13.6	13.2	-7.0
Rent	(-41.6)	1.5	-41.6	20.5	9.0	(-71.8)
Lot size	(91.0)	5.4	10.0	-29.2	9.2	-16.3
Cars	2.7	-10.2	(82.5)	29.7	-12.8	-34.2
Income	36.3	18.0	1.0	(-46.3)	(70.5)	-7.1
Family income	22.1	8.2	(92.5)	-5.2	17.7	1.1
Time of travel	22.1	(-87.7)	-5.2	-13.2	-16.4	16.9
Distance of travel	-14.2	(-91.5)	4.9	4.0	-14.1	-17.6
Eigenvalues	3.84	2.59	2.19	1.02	0.72	0.39

Table 32. Varimax Factor Matrix Male Married Ride Bus Group of Work Center E. (87.1 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	17.1	-90.5	-8.1	12.0	-12.3	-10.6	10.0
Children	26.5	-17.4	6.0	-1.2	-11.4	-1.8	(92.4)
Occupation	5.4	-8.6	1.2	(97.0)	-12.2	4.1	-1.1
Education	33.0	2.8	-5.2	4.9	-2.9	(85.3)	-4.6
Years at work	0.7	(-88.0)	-11.1	-20.0	-2.0	-10.0	-3.4
Home value	(79.3)	-36.4	13.9	-1.0	-17.2	12.7	20.5
Rent	(-90.7)	16.4	4.2	-3.6	-0.8	-18.5	-9.0
Lot size	(91.6)	-17.4	2.3	5.8	-4.4	6.5	10.4
Cars	9.1	-11.3	4.4	12.7	(-97.1)	2.2	10.2
Income	(41.8)	(-78.1)	2.8	16.9	0.0	-3.0	20.5
Family income	34.0	(-74.6)	1.4	17.5	-7.6	16.3	9.4
Time of travel	12.4	-1.0	(90.8)	1.5	-5.8	-15.4	-16.6
Distance of travel	-13.7	25.9	(64.9)	0.1	-2.3	(46.7)	17.0
Eigenvalues	4.75	1.99	1.27	1.12	0.86	0.70	0.64

Table 33. Varimax Factor Matrix Male Married Ride Bus Group of Work Center L. (90.5 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	4.5	(88.3)	17.7	-28.0	10.2	-11.2
Children	28.3	20.4	10.2	-16.7	16.4	(-87.7)
Occupation	(85.4)	18.8	-2.4	-29.2	9.1	-17.9
Education	(90.8)	-31.0	-2.8	-9.1	4.0	-5.6
Years at work	-8.7	(93.6)	-10.8	-13.1	4.5	-5.9
Home value	28.9	18.1	-5.5	-81.6	25.7	-26.1
Rent	-7.3	-22.1	-5.1	(93.1)	-12.6	-4.1
Lot size	24.1	17.4	4.1	(-91.3)	3.0	-12.8
Cars	10.9	12.4	7.9	-22.8	(94.3)	-14.3
Income	(69.3)	(50.6)	-9.4	-30.6	8.6	-29.4
Family income	(40.0)	(55.9)	-15.1	(-43.1)	12.6	-27.9
Time of travel	-2.9	8.7	(92.9)	3.7	0.1	13.5
Distance of travel	-5.3	-10.9	(87.7)	-7.0	8.2	-24.4
Eigenvalues	5.57	1.96	1.74	1.16	0.81	0.53

Table 34. Varimax Factor Matrix Male Married Drive to Work Group of Work Center B. (87.2 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	23.5	15.5	-5.0	(85.2)	8.8	-1.2	-16.9
Children	3.2	20.7	-3.3	8.9	(96.1)	-8.5	0.0
Occupation	(85.5)	4.8	6.5	11.6	4.3	5.4	14.7
Education	20.8	2.1	2.6	-5.0	0.0	-4.7	(96.4)
Years at work	20.2	14.0	-5.5	(87.7)	1.9	-12.5	8.9
Home value	18.8	(84.1)	12.7	20.9	5.0	-10.8	11.4
Rent	-4.4	(-94.3)	-2.9	-5.4	-9.8	5.9	3.7
Lot size	8.2	(91.2)	15.1	10.4	12.5	-4.2	-2.2
Cars	20.3	13.9	-3.4	11.3	9.5	(-93.4)	4.9
Income	(76.3)	18.2	-4.5	39.6	16.3	-17.0	17.4
Family income	(76.8)	12.8	-9.5	15.6	-10.6	-29.1	0.4
Time of travel	-4.2	13.0	(95.0)	0.3	-1.9	-0.1	2.2
Distance of travel	0.8	11.1	(94.4)	-10.0	-1.3	4.4	0.6
Eigenvalues	4.08	2.31	1.57	1.15	0.85	0.78	0.64

Table 35. Varimax Factor Matrix Male Married Drive to Work Group of Work Center C. (86.1 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	26.8	9.3	-7.8	-1.6	(88.1)	8.5	3.4
Children	17.8	3.3	12.5	(-93.3)	3.6	-18.3	-4.1
Occupation	6.2	31.3	6.8	-4.3	6.9	-8.5	(-92.2)
Education	-2.8	(82.8)	-0.2	-22.0	-30.6	8.0	-15.5
Years at work	31.8	-5.2	3.8	-3.0	(84.2)	-13.4	-15.4
Home value	(81.8)	30.5	12.3	0.6	25.0	-10.5	-5.8
Rent	(-93.1)	4.6	-0.3	7.1	-19.1	4.1	1.7
Lot size	(87.0)	-0.8	13.3	-20.6	23.0	-12.9	-6.1
Cars	18.6	16.6	-0.4	-20.2	1.2	(-91.2)	-8.8
Income	35.5	(68.8)	6.3	-2.6	17.2	-10.9	-36.5
Family income	-0.5	(80.1)	5.4	20.5	25.5	-33.2	-8.5
Time of travel	10.2	8.0	(88.0)	-8.6	4.8	8.2	-11.9
Distance of travel	6.3	-1.3	(90.6)	-4.0	-8.1	-8.5	4.1
Eigenvalues	4.20	2.09	1.69	1.16	0.84	0.70	0.57

Table 36. Varimax Factor Matrix Male Married Drive to Work Group of Work Center D. (88.9 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	34.5	1.1	-13.4	24.1	(80.1)	1.6	23.6
Children	15.7	2.5	5.9	(91.8)	4.8	-19.3	7.7
Occupation	12.9	(90.4)	8.6	0.2	-4.9	-4.8	-0.9
Education	-15.6	(78.0)	-9.2	13.6	8.0	0.6	-31.6
Years at work	23.9	-7.4	-6.1	9.8	25.4	-7.6	(89.2)
Home value	(78.5)	(41.3)	7.6	11.4	21.4	-7.3	8.5
Rent	(-95.0)	5.7	-0.2	-5.5	-12.1	8.8	-6.8
Lot size	(91.1)	0.1	13.4	8.4	6.2	-14.3	20.5
Cars	21.5	11.9	12.2	21.2	8.0	(-91.7)	7.2
Income	25.6	(74.1)	5.0	-13.5	35.6	16.0	30.6
Family income	4.0	(50.1)	13.6	-28.8	(66.6)	-24.4	15.0
Time of travel	3.6	4.0	(93.9)	-0.4	8.6	-4.6	-9.4
Distance of travel	10.2	1.3	(92.2)	5.8	-12.2	-7.9	5.0
Eigenvalues	4.20	2.25	1.88	1.12	1.00	0.61	0.49

Table 37. Varimax Factor Matrix Male Married Drive to Work Group of Work Center E. (87.2 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	35.7	-15.6	(82.5)	10.8	2.4	-10.1	-15.6
Children	25.4	15.0	7.7	-1.6	(91.4)	-9.3	-15.0
Occupation	12.3	2.8	6.9	-6.6	6.8	(-94.4)	1.1
Education	-2.9	0.8	-3.7	(-98.8)	1.1	-8.3	2.2
Years at work	16.4	-24.4	(87.3)	6.2	3.4	11.6	6.9
Home value	(79.7)	15.1	27.7	-2.4	4.4	-27.1	-21.2
Rent	(-89.9)	-7.0	-17.9	-4.4	-9.1	-3.4	12.2
Lot size	(87.1)	7.9	18.9	0.6	24.2	-11.9	-10.7
Cars	37.9	-0.6	19.2	6.6	19.1	0.3	(-76.0)
Income	24.5	0.0	(64.7)	-17.1	16.9	(-44.6)	-39.2
Family income	14.2	12.9	(65.1)	-9.5	3.4	(-43.3)	(-40.4)
Time of travel	9.9	(87.1)	-15.2	-8.6	-1.2	-7.2	-26.1
Distance of travel	13.7	(80.3)	-11.8	8.9	23.0	1.9	31.8
Eigenvalues	4.84	2.14	1.41	0.86	0.72	0.70	0.67

Table 38. Varimax Factor Matrix Male Married Drive to Work Group of Work Center F. (86.5 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	33.5	12.8	13.4	(66.5)	37.4	16.4
Children	16.6	-13.4	17.2	(85.0)	-16.5	-1.2
Occupation	8.4	(80.9)	12.8	-26.6	2.9	-15.3
Education	8.1	(78.5)	0.5	-21.0	-20.7	-4.4
Years at work	13.0	-3.4	-6.0	-2.1	(93.4)	-10.6
Home value	(78.7)	(49.9)	2.8	13.8	7.7	9.4
Rent	(-92.9)	-2.1	-19.2	-6.5	-8.3	3.2
Lot size	(91.1)	8.0	9.1	22.8	6.9	2.3
Cars	3.3	1.0	20.3	5.6	-9.7	(95.3)
Income	22.6	(89.5)	6.5	17.6	12.3	0.5
Family income	1.9	(86.0)	1.5	18.9	3.1	22.6
Time of travel	13.8	4.3	(94.6)	17.0	-4.3	9.1
Distance of travel	12.7	10.7	(95.4)	7.6	-1.4	14.2
Eigenvalues	4.20	2.53	1.79	1.02	0.92	0.78

Table 39 Varimax Factor Matrix Male Married Drive to Work Group of Work Center G. (82.7 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	27.6	-15.2	-5.6	11.9	(85.5)	-6.8	-8.1
Children	11.5	4.8	-10.0	9.2	5.6	(-92.0)	-6.6
Occupation	(82.6)	-13.8	-2.7	-27.2	-3.3	-14.6	1.1
Education	7.4	-7.6	-0.6	(91.7)	-8.1	-8.5	-2.7
Years at work	9.8	-11.0	-9.6	-23.7	(82.7)	-3.3	-13.9
Home value	35.3	7.5	(-58.2)	0.0	30.4	-33.8	-28.0
Rent	-4.1	-23.8	(70.5)	20.3	-16.6	34.8	13.5
Lot size	0.6	-11.5	(-87.5)	11.3	-3.6	10.3	6.1
Cars	7.4	-0.2	-6.3	2.9	16.6	-7.8	(-96.3)
Income	(79.2)	8.2	-2.0	21.7	36.8	-21.4	-6.4
Family income	(80.6)	1.3	-10.7	21.7	21.4	10.0	-9.0
Time of travel	-3.9	(91.1)	9.8	0.3	-3.6	-8.8	9.4
Distance of travel	-0.4	(87.2)	-14.7	-8.7	-19.6	1.4	-10.5
Eigenvalues	3.58	1.99	1.41	1.21	1.02	0.81	0.73

Table 40. Varimax Factor Matrix Male Married Drive to Work Group of Work Center H. (87.3 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	27.0	-11.0	(85.4)	10.0	-11.0	-9.1	13.4
Children	20.9	1.0	38.6	-1.8	(-50.0)	14.3	(40.2)
Occupation	6.8	-5.1	5.6	7.3	(-91.5)	-9.4	-10.4
Education	1.8	-10.2	2.3	(97.4)	-4.9	-2.8	1.9
Years at work	18.9	-7.4	(89.1)	-10.9	-0.7	-4.1	-0.9
Home value	(84.8)	-12.7	33.6	8.3	-9.4	-5.4	13.5
Rent	(-93.6)	-8.6	-13.3	0.8	4.5	-0.5	-4.9
Lot size	(93.3)	0.9	19.0	0.8	-7.3	-1.3	7.7
Cars	12.7	0.6	9.5	3.6	6.0	-5.3	(93.5)
Income	31.0	-15.2	(62.2)	38.5	-24.3	-23.3	20.6
Family income	2.7	-5.8	13.0	3.9	-5.0	(-97.0)	31.7
Time of travel	-3.0	(95.8)	-9.5	-7.1	3.9	5.6	-0.8
Distance of travel	3.1	(96.0)	-9.6	-6.2	1.8	1.8	1.3
Eigenvalues	4.36	2.04	1.21	1.06	0.99	0.92	0.77

Table 41. Varimax Factor Matrix Male Married Drive to Work Group of Work Center I. (88.3 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(70.9)	(-42.8)	-0.3	-24.0	16.9	19.1	-23.2
Children	4.2	-11.5	6.1	-16.2	(96.3)	12.8	-3.2
Occupation	21.3	(-60.4)	-1.8	-12.3	0.1	-17.8	(54.8)
Education	-18.8	-23.7	-16.7	-1.8	-3.6	6.4	(87.8)
Years at work	(92.5)	-5.8	-8.1	-17.7	-2.6	14.1	-0.2
Home value	16.4	(-39.9)	0.6	(-71.2)	12.9	14.1	18.3
Rent	-7.5	0.4	0.3	(94.5)	-6.6	-3.0	8.8
Lot size	18.6	-12.1	14.2	(-90.2)	7.4	10.8	6.1
Cars	25.2	-18.4	1.7	-18.5	15.0	(89.6)	1.1
Income	11.3	(-88.0)	-2.4	-13.1	19.1	9.3	22.8
Family income	8.7	(-91.3)	-6.6	-12.8	-1.4	18.6	7.9
Time of travel	-2.4	-7.6	(93.6)	-3.8	5.9	-2.2	-11.5
Distance of travel	-5.4	15.9	(93.5)	-7.3	0.5	3.8	-4.2
Eigenvalues	4.33	2.25	1.56	1.28	0.92	0.64	0.50

Table 42. Varimax Factor Matrix Male Married Drive to Work Group of Work Center J. (88.0 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(61.3)	4.1	3.0	(58.1)	-5.5	-25.4	-7.6
Children	25.0	16.7	-3.2	9.1	4.7	11.0	(-92.9)
Occupation	(75.9)	13.2	-12.9	-6.1	-10.2	24.4	-30.5
Education	24.9	8.8	-1.7	-3.4	-4.7	(93.8)	-1.8
Years at work	-3.6	16.5	-4.8	(93.5)	-2.2	2.8	-5.8
Home value	(45.3)	(81.9)	3.7	3.2	-7.5	3.5	-12.1
Rent	10.3	(-93.0)	-12.7	-8.9	9.1	-3.2	10.2
Lot size	15.6	(91.9)	14.9	12.1	0.4	6.7	-3.4
Cars	18.7	10.1	15.3	3.9	(-96.0)	4.7	3.9
Income	(89.0)	13.7	-6.9	6.0	-5.3	17.1	-21.9
Family income	(80.6)	7.6	-20.1	0.3	-10.8	8.7	5.9
Time of travel	-12.7	9.6	(92.9)	-0.6	-10.7	3.1	-1.3
Distance of travel	-14.5	17.0	(91.2)	-3.4	-5.5	-6.0	6.0
Eigenvalues	4.04	2.56	1.39	1.21	0.90	0.74	0.60

Table 43. Varimax Factor Matrix Male Married Drive to Work Group of Work Center K. (89.4 per cent)

	FACTOR						
Variable	1	2	3	4	5	6	7
Age	0.0	-17.3	28.9	11.0	16.7	3.7	(90.2)
Children	0.3	1.8	16.1	(97.1)	-3.5	11.9	9.0
Occupation	(87.4)	-1.2	15.8	-1.8	23.3	-8.1	-2.1
Education	(83.5)	8.1	-5.5	6.8	4.6	19.5	-21.7
Years at work	22.5	-11.9	7.4	-3.7	(94.0)	-1.7	15.0
Rent	-9.4	-4.2	(-89.2)	-9.6	-9.9	-5.7	-18.3
Lot size	14.5	3.1	(91.6)	7.6	8.6	-0.8	9.2
Cars	14.4	5.5	12.7	12.3	-1.6	(95.5)	2.8
Income	(86.3)	-1.7	25.3	1.9	9.1	-4.0	14.2
Family income	(80.5)	-4.8	32.6	-6.9	-4.2	28.0	15.1
Time of travel	0.9	(95.2)	2.4	2.0	-6.4	4.3	8.5
Distance of travel	0.1	(95.7)	2.0	0.0	-5.4	1.4	7.1
Eigenvalues	4.29	2.10	1.99	1.14	0.88	0.72	0.50

Table 44. Varimax Factor Matrix Male Married Drive to Work Group of Work Center L. (87.2 per cent)

	FACTOR						
Variable	1	2	3	4	5	6	7
Age	37.4	-5.9	-4.5	(83.3)	11.1	1.9	-10.6
Children	23.3	1.8	4.1	14.1	(94.3)	1.6	-16.6
Occupation	4.7	0.6	6.1	7.1	1.5	(99.2)	-3.0
Education	5.6	-1.2	93.5	4.9	1.7	5.2	1.8
Years at work	31.0	-3.8	-29.9	(79.1)	-2.3	-0.8	-2.8
Home value	(80.2)	-3.5	20.2	37.9	8.2	0.5	-10.2
Rent	(-92.4)	-7.2	2.4	-18.0	-10.2	-7.9	5.8
Lot size	(89.7)	6.8	0.9	22.4	15.0	-0.9	-10.4
Cars	17.6	4.7	-0.3	25.5	17.4	3.5	(-92.7)
Income	30.2	-7.3	45.6	(72.0)	19.8	7.2	-16.9
Family income	6.9	-5.9	32.0	(78.3)	7.6	9.3	-20.3
Time of travel	5.6	(94.9)	1.8	-3.1	2.3	0.4	-1.6
Distance of travel	2.6	(94.4)	-4.4	-8.9	-0.6	0.2	-2.4
Eigenvalues	4.88	1.93	1.32	1.06	0.82	0.81	0.54

Table 45. Varimax Factor Matrix Male Married Drive to Work Group of Work Center M. (88.2 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	14.4	-12.5	-11.7	(87.0)	0.6	-21.0	-18.6
Children	13.6	(-42.3)	1.6	18.7	-19.2	-21.9	(-78.1)
Occupation	(90.6)	-1.0	-9.0	-2.1	-17.4	-1.5	-16.9
Education	(47.9)	5.2	-3.2	1.9	-25.5	(71.9)	14.7
Years at work	34.4	-2.8	-0.8	39.2	-23.9	(-69.9)	-11.2
Home value	28.9	(-83.1)	8.6	30.6	-11.5	9.0	-10.2
Rent	11.3	(88.6)	-10.5	-2.1	-2.0	-0.0	18.9
Lot size	14.1	(-94.4)	4.2	-2.6	6.5	-12.8	-2.5
Cars	22.7	0.6	-2.1	0.0	(-94.8)	1.3	-4.7
Income	(83.3)	-24.9	5.1	30.9	-16.3	-2.1	-3.3
Family income	(64.8)	-9.8	-19.8	(57.2)	2.9	14.4	22.3
Time of travel	1.4	-13.2	(87.7)	-14.9	-7.3	-20.1	15.8
Distance of travel	-11.4	-6.3	(90.3)	-1.6	9.7	17.4	-16.8
Eigenvalues	4.04	2.56	1.59	1.29	1.00	0.56	0.43

Table 46 . Varimax Factor Matrix Male Married Drive to Work Group of Work Center N. (90.1 per cent)

Variable	FACTOR 1	2	3	4	5	6
Age	(45.6)	-15.8	30.0	13.1	(68.0)	29.1
Children	33.5	-5.9	9.2	21.3	26.9	(85.7)
Occupation	34.1	2.4	(79.4)	13.3	34.5	13.9
Education	-2.4	-7.0	(83.0)	-30.6	-31.9	-1.7
Years at work	22.2	-17.4	8.8	-0.3	(92.5)	13.3
Home value	(83.7)	-1.5	(43.5)	-4.2	10.5	14.4
Rent	(-91.4)	11.4	-4.9	-3.6	-20.9	-15.4
Lot size	(88.4)	26.0	4.8	11.8	19.4	11.3
Cars	12.6	-4.1	12.4	(93.0)	2.5	16.7
Income	34.4	-1.0	(82.0)	14.8	27.1	13.5
Family income	-1.4	-19.2	(76.0)	(39.1)	17.3	-2.9
Time of travel	16.4	(88.7)	0.7	-23.4	-13.6	8.1
Distance of travel	9.3	(91.4)	-15.1	14.6	-9.5	-14.1
Eigenvalues	5.33	2.37	1.77	1.08	0.67	0.50

Table 47. Varimax Factor Matrix Male Married Drive to Work Group of Work Center O. (88.9 per cent)

	FACTOR						
Variable	1	2	3	4	5	6	7
Age	-17.8	(83.1)	-11.4	1.5	-2.7	9.7	-23.8
Children	4.2	-0.1	10.9	(97.7)	0.0	2.1	-6.8
Occupation	(90.0)	-17.0	10.7	-1.5	1.0	0.4	-2.4
Education	(77.8)	-36.9	11.5	-18.0	-2.3	0.0	5.7
Years at work	-13.4	(-91.9)	-10.1	-2.3	6.7	-4.8	-4.6
Home value	33.8	2.7	15.5	-6.3	-7.3	-9.0	(-86.6)
Rent	5.8	-35.3	1.7	-19.2	14.4	14.0	(80.9)
Lot size	13.4	-3.0	13.7	-2.2	-2.2	(-95.9)	-16.1
Cars	17.1	-3.3	13.2	-0.4	(-95.6)	-2.0	-14.8
Income	(87.9)	4.6	8.8	10.1	-4.3	-16.7	-17.3
Family income	(83.4)	-6.9	-5.8	12.8	-28.5	-6.7	-16.4
Time of travel	12.9	-9.6	(94.5)	6.7	-7.4	-2.6	-8.0
Distance of travel	3.7	-11.5	(93.7)	5.7	-6.6	-12.8	-6.2
Eigenvalues	4.0	2.40	1.79	1.02	0.90	0.81	0.64

Table 48 . Varimax Factor Matrix Male Married Drive to Work Group of Work Center A*. (86.6 per cent)

	FACTOR					
Variable	1	2	3	4	5	6
Age	13.6	2.0	17.4	(85.8)	12.8	6.7
Children	19.8	-1.6	9.9	4.5	9.2	(96.5)
Years at work	14.9	10.3	5.3	(88.6)	-0.2	-0.7
Home value	(84.1)	-3.9	26.8	7.1	15.9	9.5
Rent	(-90.6)	8.5	2.7	-13.0	-3.1	-11.4
Lot size	(89.8)	-15.2	6.8	16.3	9.6	7.3
Cars	18.8	-4.3	7.4	10.5	(96.5)	9.3
Income	15.7	3.6	(90.3)	12.4	4.0	13.0
Family income	5.4	1.4	(92.6)	9.9	4.8	-0.8
Time of travel	7.5	(-92.4)	0.0	-1.6	3.1	7.5
Distance of travel	13.9	(-90.1)	-4.8	-10.8	1.6	-5.8
Eigenvalues	3.45	1.99	1.34	1.10	0.90	0.75

* This work place only 11 variables were observed.

Table 49. Varimax Factor Matrix Male Married Car Pool Group of Work Center L. (89.4 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	26.1	-31.3	-3.5	(75.3)	15.3	35.5	3.2
Children	15.2	-3.6	3.6	11.8	-3.9	(92.4)	-16.5
Occupation	-0.9	(94.3)	-4.9	3.9	-11.3	-3.6	11.6
Education	-0.7	-0.2	14.1	16.4	(-90.7)	6.5	9.4
Years at work	31.8	(44.3)	1.3	(40.8)	(53.3)	35.9	8.3
Home value	(88.1)	12.2	-12.0	31.0	-6.3	13.4	-0.9
Rent	(-93.9)	-6.3	-8.5	0.1	-11.9	-8.5	16.6
Lot size	19.5	(90.1)	1.4	-13.3	21.2	-2.3	-9.2
Cars	16.6	-7.8	12.1	28.7	9.8	21.5	(-84.4)
Income	8.4	-8.5	-1.5	(84.6)	-24.4	11.1	-16.0
Family income	8.0	30.9	-7.9	(75.1)	-2.1	-15.2	(-42.1)
Time of travel	0.0	-29.2	(90.0)	13.3	-8.1	0.1	0.6
Distance of travel	-1.6	27.7	(85.9)	-24.5	-8.4	4.6	-12.6
Eigenvalues	3.53	2.47	1.71	1.41	1.02	0.82	0.66

Table 50. Varimax Factor Matrix Male Married Car Pool Group of Work Center H. (89.5 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(78.7)	-15.6	-24.9	10.4	1.2	12.9	-30.0
Children	15.3	-5.3	-18.9	-6.5	4.7	(93.9)	-9.4
Occupation	(49.9)	-20.4	-31.5	7.4	23.9	(41.2)	(-47.6)
Education	-9.5	-9.6	-16.8	3.6	(96.5)	6.5	-12.3
Years at work	(92.4)	4.6	-13.7	-0.8	-4.0	8.2	-12.5
Home value	28.5	-15.6	(-78.6)	9.4	14.1	14.5	-30.6
Rent	-7.2	2.5	(90.8)	3.0	-13.1	-11.2	11.3
Lot size	18.9	-5.1	(-91.3)	3.2	2.1	10.2	-13.0
Cars	6.0	-1.0	-3.4	(98.5)	3.5	-4.7	-13.4
Income	(43.8)	-18.6	-30.1	8.6	16.7	37.5	(-65.7)
Family income	25.1	-19.0	-25.4	15.4	8.3	0.7	(-85.4)
Time of travel	1.0	(93.6)	8.4	-2.5	-11.0	-2.1	15.7
Distance of travel	-11.1	(94.6)	5.9	0.6	-1.1	-7.3	9.1
Eigenvalues	5.61	1.69	1.34	1.12	0.92	0.65	0.30

Table 51. Varimax Factor Matrix Male Married Car Pool Group of Work Center E. (86.0 per cent)

	FACTOR						
Variable	1	2	3	4	5	6	7
Age	19.8	-27.5	0.1	13.1	-2.6	6.1	(83.9)
Children	13.6	-1.1	-0.7	3.8	(96.2)	2.0	11.3
Occupation	17.5	-1.0	-1.9	1.5	3.1	(93.7)	-1.1
Education	6.9	3.1	(89.8)	-13.5	0.8	-10.7	-15.6
Years at work	6.2	-19.0	-14.5	-0.5	20.3	-11.6	(80.9)
Home value	(76.5)	19.2	17.9	-8.0	34.3	20.8	6.8
Rent	(-92.2)	6.1	3.8	-6.2	-10.7	-3.2	-10.5
Lot size	(84.7)	-8.8	10.4	16.9	-10.8	9.0	18.2
Cars	12.0	9.5	-5.8	(96.6)	3.5	25.1	10.2
Income	(44.7)	10.4	(46.6)	9.6	4.3	25.7	(61.4)
Family income	12.9	-2.6	(60.9)	24.7	-4.6	(39.5)	(50.9)
Time of travel	-0.4	(91.7)	1.1	3.1	-2.2	-9.6	-7.1
Distance of travel	-0.3	(75.3)	3.5	9.3	3.0	-13.3	(-41.1)
Eigenvalues	3.88	2.16	1.34	1.18	1.02	0.90	0.65

Table 52. Varimax Factor Matrix Male Married Car Pool Group of Work Center B. (91.0 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	-1.1	3.3	(93.3)	18.9	-5.7	12.6	6.2
Children	8.0	-15.4	18.1	-22.5	6.8	(91.8)	6.6
Occupation	(84.1)	-17.2	7.4	-20.3	-27.9	13.3	19.8
Education	19.9	-3.1	9.1	-2.3	(-96.6)	-6.4	4.5
Years at work	29.6	-27.6	6.7	-14.3	-5.8	-11.3	(81.3)
Home value	38.3	25.3	-2.7	(-74.8)	-7.9	16.9	10.7
Rent	-1.0	3.2	-3.0	(95.7)	-1.4	-10.9	-10.5
Lot size	5.7	-4.8	(93.7)	-20.9	-5.0	5.4	-7.5
Cars	18.2	11.2	-7.9	-3.5	2.5	17.7	(88.8)
Income	(64.1)	2.1	6.2	-19.5	-18.5	1.0	(64.0)
Family income	(78.7)	5.8	-4.0	-2.9	0.4	-1.2	(50.9)
Time of travel	11.6	(96.5)	3.4	-2.5	3.5	-3.3	-2.0
Distance of travel	-19.7	(93.4)	-4.9	-9.4	0.6	-12.6	-3.6
Eigenvalues	4.12	2.13	1.90	1.46	1.08	0.64	0.50

Table 53. Varimax Factor Matrix Female Married Drive to Work Group of Work Center H. (89.5 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	19.0	18.1	-8.7	(72.7)	(46.9)	2.3	8.7
Children	14.0	5.9	-2.4	-1.1	(94.2)	-4.5	-5.3
Occupation	4.6	9.5	5.0	1.8	5.1	3.9	(96.1)
Education	4.3	(70.0)	-19.9	-19.8	-17.6	-11.4	37.2
Years at work	12.8	-5.2	0.4	(93.3)	-15.7	0.7	8.1
Home value	(89.8)	13.9	1.7	16.2	17.7	7.9	14.7
Rent	(-92.4)	1.2	-23.9	-5.4	-2.6	-5.3	3.4
Lot size	(93.7)	3.5	15.7	9.1	4.4	8.3	1.2
Cars	15.1	3.0	8.1	1.6	-4.0	(97.3)	7.1
Income	6.3	(44.2)	-11.1	31.4	-18.3	10.0	(69.9)
Family income	8.9	(84.8)	3.3	16.5	27.1	10.7	7.2
Time of travel	18.6	-0.9	(95.1)	-5.0	-3.0	4.7	2.3
Distance of travel	16.1	-9.9	(95.3)	-0.2	-0.8	4.9	-4.1
Eigenvalues	3.53	2.56	1.64	1.26	1.10	0.88	0.66

Table 54. Varimax Factor Matrix Female Married Drive to Work Group of Work Center G. (89.5 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	31.1	(69.9)	-24.9	-16.4	-7.5	-33.5	24.5
Children	24.1	-13.6	-82.7	20.7	1.1	-11.8	23.0
Occupation	12.4	12.2	-0.1	0.6	4.8	(-94.4)	5.3
Education	-2.0	-24.6	(74.9)	-7.4	-2.0	-30.1	36.1
Years at work	12.4	(91.5)	6.3	-6.4	3.5	-20.8	0.6
Home value	(87.6)	14.9	-16.3	7.0	14.2	-17.4	18.0
Rent	(-95.7)	-10.1	6.7	-9.9	-4.2	4.5	2.6
Lot size	(91.3)	10.5	-5.3	24.2	5.4	-7.2	5.4
Cars	15.2	-0.4	-17.6	6.4	(97.1)	2.6	14.1
Income	11.1	(41.4)	11.1	-4.7	-1.6	(-81.0)	19.3
Family income	11.4	12.9	0.2	-0.6	15.5	-14.9	(92.7)
Time of travel	10.4	-1.6	-12.1	(91.4)	5.9	-3.4	-2.1
Distance of travel	21.9	-13.4	-8.7	(88.6)	1.4	7.8	0.8
Eigenvalues	4.04	2.62	1.39	1.15	1.02	0.78	0.64

Table 55. Varimax Factor Matrix Female Married Drive to Work Group of Work Center F. (85.5 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	25.9	3.5	16.4	(81.1)	15.4	-8.0	-5.5
Children	7.2	-11.2	-3.2	(86.5)	-5.1	17.8	-9.1
Occupation	0.1	(86.8)	3.3	-4.9	3.5	15.2	15.4
Education	4.2	6.5	-7.9	-13.6	13.2	6.6	(95.3)
Years at work	2.9	(84.1)	1.6	-2.7	22.2	-9.4	-8.0
Home value	(90.3)	-3.6	3.4	15.2	22.0	8.6	6.6
Rent	(-91.2)	-6.9	-13.2	-10.1	-3.3	-13.0	4.6
Lot size	(94.6)	1.7	8.2	11.2	11.6	5.2	5.2
Cars	20.0	5.6	-2.1	9.3	16.0	(93.4)	7.2
Income	13.6	35.5	4.6	-5.1	(81.3)	0.9	-3.3
Family income	22.2	-0.9	-3.7	17.0	(76.6)	23.3	26.7
Time of travel	9.4	-0.3	(93.5)	5.8	-3.8	1.0	-0.6
Distance of travel	10.0	5.5	(92.3)	4.4	5.2	-3.3	-7.9
Eigenvalues	3.65	2.07	1.74	1.21	1.02	0.77	0.65

Table 56. Varimax Factor Matrix Female Married Drive to Work Group of Work Center E. (88.7 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(86.5)	-7.6	-26.9	0.7	23.1	-16.3	-14.5
Children	9.2	-4.1	-12.5	5.4	(95.5)	-7.1	-4.3
Occupation	13.9	14.8	-11.1	-17.8	16.4	-9.0	(-90.5)
Education	2.0	-2.3	-9.7	(-95.4)	-5.5	2.0	-19.1
Years at work	(91.4)	6.0	-18.8	-2.3	-2.6	-9.4	-21.2
Home value	27.0	22.6	(-81.2)	-18.3	-4.3	-14.3	-20.0
Rent	-14.3	-0.5	(94.0)	-3.8	-7.6	8.5	4.7
Lot size	15.0	20.6	(-89.4)	-7.0	14.1	-14.9	-8.0
Cars	8.5	5.1	-19.5	11.3	18.2	(-88.2)	-12.7
Income	(44.8)	9.3	-17.9	-10.8	-18.4	-24.0	(-72.8)
Family income	(40.8)	25.4	-14.4	-22.4	-20.5	(-62.7)	-17.8
Time of travel	10.4	(84.8)	-27.0	-10.7	0.4	-7.5	-2.9
Distance of travel	-7.6	(88.8)	-3.7	11.5	-5.2	-8.6	-15.9
Eigenvalues	4.88	1.64	1.56	1.18	0.94	0.77	0.56

Table 57. Varimax Factor Matrix Female Married Drive to Work Group of Work Center D. (88.7 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(84.3)	-7.8	5.0	-19.9	30.1	16.9	6.0
Children	17.1	-16.0	4.9	-2.4	2.2	-4.7	(95.6)
Occupation	-12.8	(84.8)	-18.7	-5.9	10.8	6.9	-2.5
Education	-25.5	(80.9)	-2.0	-8.9	-12.4	17.6	(-28.3)
Years at work	(79.0)	-8.9	-23.2	-28.0	31.6	-3.8	-15.4
Home value	(87.1)	0.2	7.8	23.4	11.0	-6.6	12.3
Rent	(-86.3)	21.7	-1.8	-20.7	16.7	8.8	-11.5
Lot size	(89.5)	-10.2	4.0	25.8	1.0	2.0	23.9
Cars	33.1	(52.2)	32.4	(40.9)	24.8	-8.4	32.2
Income	-0.1	15.8	-3.7	6.0	14.2	(96.4)	-5.1
Family income	17.1	5.3	3.8	12.2	(92.1)	14.8	3.4
Time of travel	0.3	16.4	(-90.0)	23.6	-3.5	3.2	-4.7
Distance of travel	13.9	-12.0	-31.8	(85.3)	11.5	8.2	-4.3
Eigenvalues	4.49	2.07	1.37	1.21	1.02	0.70	0.67

Table 58 Varimax Factor Matrix Female Married Drive to Work Group of Work Center I. (87.0 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	30.2	(73.2)	-9.3	25.7	-11.0	10.9	35.6
Children	28.2	1.6	8.7	12.2	6.3	-11.5	(86.4)
Occupation	2.4	-1.7	-4.8	-0.5	(-93.2)	15.3	7.9
Education	-9.9	0.5	0.1	-2.5	-16.3	(96.5)	-9.8
Years at work	20.7	(91.8)	1.1	6.3	-12.1	-6.0	-11.7
Home value	(90.5)	18.4	13.6	19.4	-7.0	0.0	10.4
Rent	(-88.1	-13.8	-17.6	0.2	0.0	17.6	-16.7
Lot size	(89.4)	17.5	23.2	11.2	-2.7	1.2	12.1
Cars	1.4	17.6	5.7	(80.4)	5.0	-10.9	30.5
Income	6.2	(40.6)	4.6	18.3	(-76.1)	3.4	-24.4
Family income	37.8	7.6	-7.7	(70.1)	-28.3	11.3	-18.9
Time of travel	24.9	-5.2	(87.5)	12.7	-1.5	2.0	1.8
Distance of travel	14.9	1.3	(90.5)	-11.4	3.9	-2.7	6.4
Eigenvalues	4.16	2.25	1.51	0.96	0.90	0.78	0.73

Table 59. Varimax Factor Matrix Female Married Drive to Work Group of Work Center J. (88.6 per cent)

	FACTOR						
Variable	1	2	3	4	5	6	7
Age	32.3	18.7	6.8	(71.7)	6.3	(-46.0)	11.5
Children	20.4	8.8	2.2	(92.7)	4.3	11.3	-14.7
Occupation	-4.0	(78.3)	5.0	5.0	0.1	-25.1	17.6
Education	-15.0	22.5	-11.3	-8.3	4.1	3.5	(93.8)
Years at work	28.7	25.6	7.5	2.0	5.9	(-88.6)	-5.7
Home value	(91.3)	17.3	5.4	21.5	0.8	-9.2	2.8
Rent	(-92.9)	5.9	-13.8	-4.4	-2.8	9.9	15.7
Lot size	(89.4)	12.1	10.5	23.5	12.5	-20.1	-9.6
Cars	8.8	14.9	1.9	6.4	(97.7)	-5.4	-3.6
Income	0.0	(79.2)	-3.5	23.5	5.3	-15.5	19.2
Family income	28.4	(79.0)	-3.8	-3.2	17.1	6.9	-7.5
Time of travel	3.9	-1.8	(94.5)	7.37	0.2	-16.8	0.1
Distance of travel	19.1	0.1	(93.1)	-1.5	2.3	8.4	-12.5
Eigenvalues	4.20	2.31	1.54	1.06	0.98	0.79	0.64

Table 60. Varimax Factor Matrix Female Married Drive to Work Group of Work Center K. (88.6 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(45.3)	26.2	-5.3	21.8	13.8	-3.0	(67.2)
Children	34.9	-14.2	-0.3	1.2	-11.7	-5.5	(85.8)
Occupation	-8.9	(86.5)	-7.3	-4.0	22.4	-19.1	-4.2
Education	1.6	18.4	2.1	-6.6	(95.7)	-10.4	-2.5
Years at work	25.7	(81.6)	-5.1	13.3	-11.4	17.4	12.3
Home value	(84.9)	8.5	-5.2	5.5	16.5	-16.2	26.2
Rent	(-92.2)	-4.3	4.8	1.0	4.9	5.4	-19.3
Lot size	(91.7)	7.8	7.7	6.5	-7.8	-7.3	15.9
Cars	6.8	2.9	1.7	(97.0)	-6.6	-12.2	9.6
Income	8.1	(92.0)	-13.3	-2.3	15.3	-15.8	-5.0
Family income	21.1	13.8	-0.5	13.6	11.0	(-92.5)	6.4
Time of travel	6.1	-7.5	(92.9)	-8.4	-6.9	-5.6	5.3
Distance of travel	-8.0	-12.5	(91.8)	10.5	8.9	6.8	2.2
Eigenvalues	3.96	2.56	1.61	1.08	1.04	0.72	0.55

Table 61. Varimax Factor Matrix Female Married Drive to Work Group of Work Center B. (88.9 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(82.6)	-18.2	1.0	-19.1	-8.5	19.4	2.2
Children	31.0	-10.8	-4.0	-4.9	-8.4	(90.7)	-6.3
Occupation	25.4	13.8	6.3	-14.3	-9.5	1.3	(-89.2)
Education	-29.4	-10.4	(59.3)	-11.3	18.1	24.8	(-53.1)
Years at work	(87.9)	-21.9	9.6	1.0	-2.4	12.8	-14.1
Home value	27.0	(-85.5)	22.0	5.5	-9.9	16.5	4.6
Rent	-13.3	(94.5)	8.1	-7.0	13.6	0.3	-4.1
Lot size	11.1	(-93.5)	2.7	16.6	-1.7	3.0	1.3
Cars	4.8	-17.8	6.9	6.5	(-95.8)	7.4	-4.3
Income	(66.6)	-16.4	(43.7)	-14.8	6.2	9.6	(-40.3)
Family income	26.8	-3.1	(88.9)	-3.7	-14.6	-11.7	-2.6
Time of travel	-16.3	-1.1	1.4	(90.1)	-13.6	4.5	22.3
Distance of travel	-9.7	-27.6	-11.8	(88.0)	5.8	-11.4	-2.7
Eigenvalues	3.88	2.76	1.37	1.08	0.92	0.88	0.67

Table 62. Varimax Factor Matrix Female Married Car Pool Group of Work Center L. (87.6 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(84.3)	-3.8	-0.2	-1.2	-32.6	21.7	-13.1
Children	-2.9	-12.6	-29.9	-4.6	-20.8	(79,8)	-14.2
Occupation	8.1	1.0	(93.9)	-6.4	6.5	-10.6	11.0
Education	-4.4	5.9	11.9	2.9	10.2	-3.1	(97.2)
Years at work	(90.1)	-1.7	-7.2	2.1	-26.7	-9.7	-8.7
Home value	27.9	-2.8	5.7	6.5	(-86.5)	25.0	-6.9
Rent	-17.6	11.6	6.2	-7.8	(91.7)	-1.6	4.4
Lot size	21.1	-26.7	-8.9	3.6	(-88.1)	11.2	-4.6
Cars	11.6	-16.1	-6.4	(94.6)	-10.5	6.8	2.4
Income	(78.2)	0.0	32.3	25.1	-9.9	12.8	19.4
Family income	35.0	13.4	23.4	27.9	-11.8	(62.9)	17.5
Time of travel	11.0	(-92.1)	-4.3	3.7	-9.9	3.4	-3.1
Distance of travel	-8.7	(-89.6)	2.0	13.0	-19.6	0.2	-4.2
Eigenvalues	4.33	2.10	1.46	1.10	1.00	0.76	0.64

Table 63. Varimax Factor Matrix Female Married Car Pool Group of Work Center I. (92.1 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	17.6	-18.9	(-53.7)	2.7	-15.8	-3.9	(-73.1)
Children	-3.3	-8.7	(-95.2)	-7.0	-13.8	-14.2	-10.1
Occupation	(91.8)	-3.3	-5.1	19.2	-9.4	3.5	-18.0
Education	18.6	-12.6	6.0	(95.8)	6.7	7.0	-3.5
Years at work	(49.2)	11.3	0.0	-2.4	-16.0	1.1	(-81.1)
Home value	26.9	-3.9	-4.8	11.4	(-50.6)	-25.9	(-71.8)
Rent	-14.1	-15.7	22.9	12.7	(87.1)	10.2	20.1
Lot size	8.8	28.0	-1.8	1.5	(-88.6)	-15.6	(-17.8)
Cars	-20.1	29.5	-9.4	-17.9	-21.2	(-83.2)	-1.9
Income	(88.5)	-14.8	6.0	5.0	-12.1	3.6	-31.5
Family income	(45.5)	-27.5	-29.3	19.5	-15.0	(-60.2)	-26.4
Time of travel	-6.4	(94.9)	1.7	-7.5	-11.2	-8.1	-7.4
Distance of travel	-10.1	(88.0)	14.9	-9.0	-28.9	-6.5	14.2
Eigenvalues	4.54	2.99	1.69	0.86	0.70	0.66	0.54

Table 64. Varimax Factor Matrix Female Married Car Pool Group of Work Center E. (90.6 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	(80.6)	-11.3	-7.2	-30.0	-32.8	9.0	-20.3
Children	18.8	0.3	5.3	-8.1	(-95.5)	11.7	-6.5
Occupation	21.5	27.8	36.9	-32.7	-19.2	-18.4	(-64.6)
Education	-17.8	0.7	(89.9)	-21.4	-3.8	-6.4	-14.8
Years at work	(83.8)	7.1	-9.1	-30.4	-7.0	19.3	-22.8
Home value	(41.5)	20.7	20.2	(-67.5)	-17.4	14.2	-38.5
Rent	-16.7	-12.1	-15.0	(91.9)	-1.8	-15.4	7.0
Lot size	35.4	22.7	15.1	(-75.7)	-18.0	28.1	-24.3
Cars	22.6	11.1	-4.4	-33.0	-15.0	(86.7)	-8.4
Income	(61.1)	17.4	(65.3)	-7.0	-3.2	12.0	-24.1
Family income	(39.5)	-8.6	16.9	-18.2	-0.8	24.4	(-76.6)
Time of travel	8.0	(87.9)	9.6	-7.3	-10.2	17.4	-27.5
Distance of travel	-4.9	(90.1)	0.3	-21.3	8.7	-3.9	16.8
Eigenvalues	5.80	1.83	1.41	0.92	0.81	0.58	0.43

Table 65. Varimax Factor Matrix Female Married Car Pool Group of Work Center H. (92.1 per cent)

Variable	FACTOR 1	2	3	4	5	6	7
Age	35.3	3.7	(71.5)	-16.5	(40.2)	-31.3	12.8
Children	12.1	16.0	6.1	7.7	(93.8)	-19.0	13.4
Occupation	-6.3	-13.7	(90.2)	17.5	4.6	-4.6	-2.8
Education	-15.9	17.5	-1.8	(95.1)	5.6	-7.6	-1.3
Years at work	17.6	-28.0	(81.3)	-21.4	-11.1	-26.0	0.7
Home value	(87.8)	0.4	15.9	-2.9	20.0	-25.5	14.5
Rent	(-91.2)	27.1	-1.6	14.0	-4.5	2.0	-5.7
Lot size	(92.8)	-10.2	7.6	-7.1	-0.8	-18.2	17.9
Cars	33.0	-27.0	0.5	-1.6	17.4	-15.1	(86.6)
Income	18.2	(-41.0)	34.9	23.6	17.4	(-69.8)	-5.8
Family income	24.7	0.0	17.6	-0.9	15.7	(-87.7)	18.9
Time of travel	9.2	(-92.8)	13.5	-8.8	-5.5	-8.1	17.7
Distance of travel	18.9	(-90.6)	17.0	-14.1	-14.4	-6.9	7.2
Eigenvalues	5.06	2.10	1.96	1.10	0.81	0.59	0.36

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VITA

George Ely Mouchahoir was born in Jerusaleum, Palestine on February 1, 1941, the son of Ely and Edibeh Mouchahoir. He received his early education at the Holy Heart Christian Brothers College in Beirut, Lebanon. In 1965 he graduated from the American University of Beirut, Lebanon with a Bachelor of Engineering (Major: Civil).

The author practiced civil engineering in Lebanon and in Holland. In September, 1966, he was awarded a scholarship from the Lebanese Ministry of Education to do graduate work in City Planning. At this time, he entered the Georgia Institute of Technology and in 1969 he was awarded the two degrees: Master of City Planning and Master of Science in Civil Engineering (Major: Transportation).

After that time, the author pursued his graduate study towards a Ph.D. degree in Civil Engineering at the Georgia Institute of Technology. During this time, he served as a Graduate Research Assistant in the School of Civil Engineering.

A Lebanese citizen, Mr. Mouchahoir is engaged to Miss Enid Siffri of Jerusaleum, Palestine.